ANNALS
OF
SURGERY.

A MONTHLY REVIEW OF SURGICAL SCIENCE AND PRACTICE

EDITED BY
LEWIS STEPHEN PILCHER, M.D., LL.D.,
OF NEW YORK.

WITH THE COLLABORATION OF

J. WILLIAM WHITE, M.D., LL.D.,
OF PHILADELPHIA,
Professor of Surgery in the University of Pennsylvania.

SIR WILLIAM MACEWEN, M.D., LL.D.,
OF GLASGOW,
Professor of Surgery in the University of Glasgow.

SIR W. WATSON CHEYNE, C.B., F.R.S.,
OF LONDON,
Professor of Surgery in King's College.

VOLUME LXIII
JANUARY—JUNE, 1916

PHILADELPHIA
J. B. LIPPINCOTT COMPANY
1916

CONTRIBUTORS TO VOLUME LXIII

ARMITAGE, GEO. L., JR., M.D., of Chester, Pa.

ARMITAGE, H. M., M.D., of Chester, Pa.

ASHHURST, ASTLEY PASTON COOPER, M.D., of Philadelphia, Pa.

BALFOUR, DONALD C., M.D., Mayo Clinic, Rochester, Minn.

BARTLETT, WILLARD, M.D., of St. Louis, Mo.

BEHAN, R. J., M.D., of Pittsburg, Pa.

BOLLING, R. W., M.D., of New York.

BONN, HARRY K., of Indianapolis, Indiana.

BOORSTEIN, SAMUEL W., M.D., of New York.

BRYAN, ROBERT C., M.D., of Richmond, Virginia.

COHN, ISIDORE, M.D., of New Orleans, La.

COLEY, WILLIAM B., M.D., of New York.

COTTON, FREDERIC J., M.D., of Boston, Mass.

DA COSTA, JOHN CHALMERS, M.D., of Philadelphia.

DARRACH, WILLIAM, M.D., of New York.

DAVIS, BENJAMIN FRANKLIN, M.D., of Chicago, Illinois.

DEAVER, JOHN B., M.D., of Philadelphia.

DODGE, GEORGE E., M.D., of Tuscon, Arizona.

DOWD, CHARLES N., M.D., of New York.

DURANTE, LUIGI, M.D., of Rochester, Minn.

EASTMAN, JOSEPH RILUS, M.D., of Indianapolis, Indiana.

ELIOT, ELLSWORTH, JR., M.D., of New York.

ERDMAN, BERNHARD, M.D., of Indianapolis, Indiana.

FALK, HENRY C., M.D., of New York.

FAUNTLEROY, A. M., M.D., of Washington, D. C.

FERGUSON, L. M., M.D., of Pittsfield, Mass.

CONTRIBUTORS TO VOLUME LXIII

FLINT, JOSEPH MARSHALL, M.D., of New Haven, Conn.

FLUMERFELT, GERTRUDE, M.R.C.S. (Eng.), L.R.C.P. (Lond.), of Victoria, B. C.

FRAZIER, CHARLES H., of Philadelphia.

FREEMAN, LEONARD, M.D., of Denver, Colorado.

GAUDIANI, VINCENT, M.D., of New York.

GIBSON, CHARLES LANGDON, M.D., of New York.

GINSBURG, NATHANIEL, M.D., of Philadelphia.

GOODMAN, CHARLES, M.D., of New York.

GOODMAN, EDWARD H., M.D., of Philadelphia, Pa.

GREEN, NATHAN W., M.D., of New York.

GREGOR, GILBERT D., M.D., of Watertown, N. Y.

GREY, ERNEST G., M.D., of Boston, Mass.

GUTHRIE, DONALD, M.D., of Sayre, Pa.

HAUSSLING, F. R., M.D., of Newark, N. J.

HENDERSON, MELVIN S., M.D., Mayo Clinic, Rochester, Minn.

HENDRIX, B. M., Ph.D., of Philadelphia.

HITZROT, JAMES MORLEY, M.D., of New York.

HORSLEY, J. SHELTON, M.D., of Richmond, Virginia.

HUBBARD, JOSHUA C., M.D., of Boston, Mass.

JEFFERSON, GEOFFREY, M.S. (Lond.), F.R.C.S. (Eng.), of Victoria, B.C.

JONES, JOHN F. X., M.D., of Philadelphia, Pa.

LEE, BURTON J., M.D., of New York.

LEWALD, LEON T., M.D., of New York.

LEWISOHN, RICHARD, M.D., of New York.

LONG, JOHN WESLEY, M.D., of Greensboro, N. C.

LOWER, WILLIAM E., M.D., of Cleveland, Ohio.

LYLE, HENRY H. M., M.D., of New York.

MACCARTY, WM. CARPENTER, M.D., of the Mayo Clinic, Rochester, Minnesota.

CONTRIBUTORS TO VOLUME LXIII

MARTIN, WALTON, M.D., of New York.

MARTLAND, H. S., M.D., of Newark, N. J.

MATHEWS, FRANK S., M.D., of New York.

MAYO, CHARLES H., M.D., of Rochester, Minnesota.

MCCARTY, FRANKLIN B., M.D., of Chicago, Illinois.

MCWHORTER, JOHN L., of New York.

MCWILLIAMS, CLARENCE A., M.D., of New York.

MEYER, WILLY, M.D., of New York.

MOORE, JAMES E., M.D., of Minneapolis, Minn.

MOSCHCOWITZ, ELI, M.D., of New York.

MOULLIN, C. MANSELL, M.D. (Oxon.), of London.

MURRAY, R. W., F.R.C.S., of Liverpool, England.

NEUHOF, HAROLD, M.D., of New York.

PEET, MAX M., M.D., of Philadelphia.

PETERKIN, SHEARMAN G., M.D., of Seattle, Washington.

PIPER, EDMUND B., M.D., of Philadelphia.

POOL, EUGENE H., M.D., of New York.

POPE, SAXTON, M.D., of San Francisco, Cal.

PRIME, FREDERICK, of New York.

QUILLIAN, GARNETT W., M.D., of Atlanta, Ga.

REMSEN, CHARLES M., M.D., of Atlanta, Ga.

RHODES, GOODRICH B., M.D., of Cincinnati, Ohio.

ROBERTS, JOHN B., M.D., of Philadelphia.

ROBINSON, ERNEST F., M.D., of Kansas City, Mo.

ROCKEY, A. E., M.D., of Portland, Oregon.

ROGERS, ALLEN, Ph.D., of Brooklyn, N. Y.

ROSENBERGER, RANDLE C., M.D., of Philadelphia, Pa.

SEKIGUCHI, SHIGEKI, M.D., of Japan.

CONTRIBUTORS TO VOLUME LXIII

SHAW, HARRY A., M.D., of Seattle, Wash.

SHROPSHIRE, COURTNEY W., M.D., of Birmingham, Ala.

SKILLERN, PENN G., JR., M.D., of Philadelphia.

SLOCUM, MORRIS A., M.D., of Philadelphia.

SMITS, J. C. J. C., M.D., of Sumatra.

SPEESE, JOHN, M.D., of Philadelphia.

SWEET, J. E., M.D., of Philadelphia.

TROELL, ABRAHAM, M.D., Stockholm, Sweden.

WALKER, M. H., JR., M.D., of Pittsfield, Mass.

WATTERSTON, CHAS., M.D., of Birmingham, Ala.

WIGHT, J. SHERMAN, M.D., of Brooklyn, N. Y.

WILLIAMS, HADLEY, F.C.R.S. (Eng.), of London, Canada.

Vol. LXIII JANUARY, 1916 No. 1

ANNALS of SURGERY

A Monthly Review of Surgical Science and Practice

Edited by
LEWIS STEPHEN PILCHER, M.D., LL.D.
of New York

With the Collaboration of
J. WILLIAM WHITE, M.D., LL.D. of Philadelphia
SIR WILLIAM MACEWEN, M.D., LL.D. of Glasgow
SIR W. WATSON CHEYNE, C.B., F.R.S. of London

J. B. LIPPINCOTT COMPANY, PUBLISHERS
MONTREAL PHILADELPHIA LONDON

Entered at the Post-Office at Philadelphia and admitted for transmission through the mails at second-class rates. Price $5.00 a year.

This is the eighth of a series of articles on the uses of Stanolax—tasteless, odorless, liquid paraffin.

The facts presented in this series of announcements are based on authoritative clinical data.

Made from American Petroleum

For Auto-Intoxication

STANOLAX LIQUID PARAFFIN is a solvent of intestinal toxins, which makes its use especially effective in the treatment of auto-intoxication.

It lubricates the entire alimentary tract, is non-absorbable and non-irritating, making it an ideal protective agent.

It is a gentle, effective corrective for chronic constipation and intestinal stasis. It is prepared under absolutely aseptic conditions. Guaranteed as to purity, uniformity, etc., by the Standard Oil Company.

Stanolax Liquid Paraffin

Kellog, J. H. (New York M. J., 1914, C 504) says:—One interesting feature of liquid paraffin is its behavior toward intestinal toxins. These consist not only of bile acids and alkaline wastes excreted by the intestinal mucous membrane, but also of ptomaines and toxins produced through bacterial action in the colon, and the small intestine, especially in cases of incompetency of the ileocecal valve. Liquid paraffin is a highly active solvent and readily dissolves these wastes and poisonous substances. The result is that the paraffin oil, itself not absorbable, takes up a very considerable portion of the toxins found present in the intestinal tract, thus preventing their absorption. When paraffin oil is used, it may always be seen in the stools, showing a brownish or blackish color, due to the substance which it holds in solution. In a laboratory test, it was found that when paraffin oil was shaken with a watery solution of indol, more than half the indol was quickly taken up by the paraffin.

* * * * *

A trial quantity and fully descriptive booklet will be sent gladly on request.

STANDARD OIL COMPANY
(INDIANA)
CHICAGO, U. S. A.

(432)

ANNALS *of* SURGERY

VOL. LXIII JANUARY, 1916 No. 1

GAS BACILLUS INFECTION

BY A. M. FAUNTLEROY, M.D.
OF WASHINGTON, D.C.
SURGEON U. S. NAVY

IT has been rightly suggested that the term "gas gangrene" is a misnomer, in that it does not convey a scientifically correct etiological or pathological idea as regards the nature of this condition. As a substitute, the term "gas infection" has been used by many as being more appropriate, since it expresses more accurately the general character of a process in which a number of factors have to be considered in order to arrive at a correct understanding of the condition.

The infection of wounds by gas-producing organisms is by no means a new condition. Attention has been repeatedly called to infections in previous wars which have resulted in an emphysematous condition of the tissues; while the anaërobic character of the organisms involved has been recognized for a number of years. In the present war, the nature of the battle-ground, the concentration of large numbers of individuals, and the underground methods of warfare have all combined to accentuate the presence of this infection and caused it to assume a prominent role in present-day military surgery.

The Welch bacillus has been long known as an anaërobic gas-producing organism, capable of infecting wounds, and causing more or less serious complications. Until the outbreak of the present war, surgeons and bacteriologists have not had sufficient experience to justify a positive opinion, as regards the etiological relationship of this and other gas-forming organisms, in the production of what has been called "gas gangrene." The reason for this reservation has been due to the fact that numerous other organisms have been almost invariably recorded as accompanying an infection of this kind; and also due to the fact that certain heretofore unidentified organisms, resembling the Welch bacillus, were seemingly also causative factors. In addition to this, chains of cocci organisms have been thought at times to have been able to assume a gas-producing role. The other organisms

which have been found in gangrenous tissues and discharges, where gas has been present, are the colon, proteus and other putrefactive bacilli.

For several months after the present European war began the unidentified gas-producing bacilli, resembling the Welch bacillus, were known as the bacillus "perfringens," on account of certain cultural peculiarities which seemingly could not be reconciled with the cultural characteristics of the Welch bacillus. However, as time went on and the bacteriological technic of war hospital laboratories was more perfected, it became more and more apparent to careful observers that the perfringens was really a strain of the Welch organism; and, at the present time, laboratory men of large experience are practically unanimous in pronouncing them identical. The first definite case in which the bacillus was isolated from the blood, sufficiently early after death to completely establish its etiological role, occurred at the American ambulance during the early part of the present year. At this time, a culture of the heart's blood, three hours after death, gave a pure culture of *B. perfringens.* Since that time, instances have multiplied in which the same organism has been isolated from the blood during life in seriously infected cases. Not infrequently a pure culture has been obtained from the wounds of undeniable clinical cases and the condition reproduced clinically in guinea-pigs after the tissues of the latter had been injured. Only after previous injury to the tissues of the guinea-pig could the progressive gangrenous condition be produced. At the Pasteur Institute it was said that an injury to the guinea-pig's muscle was sufficient trauma to cause reproduction of the process.

Etiology.—As regards the conditions which are favorable for gas bacillus infection of wounds, it is to be noted that the *B. perfringens* has been found in the culture from many cases which present no clinical evidence of this form of specific infection. In fact, it is most unusual in base hospital work to examine the discharges from a wound and not be able to find the *B. perfringens* associated with either the staphylococcus, streptococcus or other organisms. Its practically universal presence in the discharges and tissues of all wounds of the present war, which show any signs of infection, would seem to indicate that the conditions for bringing about an infection with this organism are easily accomplished. That this organism flourishes in the soil, and is to be found in every locality where the present trench warfare is conducted, leads to the belief that the primary source of infection is in the dirt from the trenches in which the combatants are forced to live for days. The organism has been many times demonstrated in the outer clothing of soldiers, so that it is easy to understand its presence in wounds where

bits of clothing are to be found. The soldier invariably comes from the trenches or dug-outs in a muddy or dusty condition, which latter is due to prolonged and intimate contact with the soft and ofttimes rain-soaked earth. Under these circumstances, even when clothing is not present in the wound, it is an easy matter for the omnipresent *B. perfringens* to ultimately find its way into the skin openings.

The very fact that the organism finds such easy access to all wounds, and also apparently finds in the latter a suitable culture medium without always manifesting itself, suggests the necessary presence of other conditions, notably in the wound, before it begins to exhibit its virulency as regards specific gas infection. The pathology of the lesions which show clinical signs of this condition is generally of a uniform character. Invariably there is more or less pulpification of the tissues, associated usually with fracture of the bone, and there is evidence in every case of more or less circulatory disturbance. This latter may manifest itself by a frank blood-vessel injury, which of necessity would interfere with the nutrition of the part, or there may be evidence after some days of thrombosis, inflammatory swelling, and slight œdema or skin mottling, any of which would indicate a certain degree of embarrassment to the nutrition of the part. There is some dispute as to whether the injury of a large blood-vessel is one of the necessary factors for the development of a clinical case. Whether this is true or not, it would seem to be essential for the growth and progressive virulency of the organism that a certain amount of devitalized tissue be present in the wound. The organism unquestionably thrives best in the presence of necrotic material, whether this necrosis be due to a limited pulpification, with or without injury to a large blood-vessel, or whether the subsequent sloughing be due to a secondary interference with the circulation.

A fatal case of gas bacillus infection is one that has passed through the progressive steps of (1) injury, (2) infection, (3) localized necrosis, (4) progressive gas production, (5) circulatory disturbance, (6) increased virulence, and, last, septicæmia. By timely and proper surgical measures, the progress of the process may be arrested and eventually cured; or the open character of the wound may be originally such as to render the essential anaërobic growth of the organism a difficult matter. Thus it is that one may see various degrees of gas bacillus infection depending upon character of the wound, time and nature of the surgical interference, and efficiency of the after-treatment.

Pathology.—Besides the extensive destruction and necrosis of the tissues immediately adjacent to the wound, there is marked parenchy-

matous degeneration of the muscles above and below the wound, and more or less marked œdematous infiltration interspersed with gas bubbles of varying sizes. The toxins formed by the *B. perfringens* would seem to exert a special selective action on the planes of connective tissue, since it has been often noted at operation and at autopsy that the necrosis has travelled with apparent greater rapidity along the fascial planes, which latter are often found to be much more extensively necrotic than the adjoining muscular tissue. The resistance of the tissues surrounding the wound is thus progressively lowered, and the subsequent necrosis increases the activity of the organisms, so that a vicious circle is rapidly established in which necrosis follows bacterial activity while the latter increases and becomes more virulent as a result of the necrosis. The outer walls of the blood-vessels in the immediate neighborhood of the infective process are also apparently specifically acted upon by the toxins, and this very probably accounts for the extravasated blood so often seen beneath the skin, or in the adjacent tissues, which in turn gives rise to the superficial mottling or discoloration.

Externally, the appearance of a gas-bacillus infected limb depends on the stage and degree of infection. In the earlier stages nothing is usually apparent, beyond the nature of the wound, to indicate the gravity of the process. In from two to five days, however, in those cases in which the process is following the stages already indicated, there is apparent a certain though small degree of swelling; palpation will usually elicit the presence of gas in the tissues, as indicated by the crepitation, and there is also usually to be noted the loss of a certain degree of tissue elasticity almost resembling induration; a slowly progressive brownish or copper-colored mottling of the skin adjacent to the wound; a more or less characteristic and marked fetid odor, resembling somewhat the pungent, sweetish stench of dead fish; the discharge from the wound, unless there is a mixed infection, is usually of a thin serosanguinous character which is not infrequently mud-colored; and, last, the more or less sudden appearance of crops of vesicles which vary in size from that of a pea to several inches in diameter. Although a pulse may be noted in one of the arteries distal to the wound, during the earlier stages of the infection, it becomes progressively weaker and in the last stage is always absent.

The fluid in the vesicles or blebs is of a serosanguinous character and not infrequently straw-colored. Rather rarely the fluid will show the presence of *B. perfringens,* but in most instances no bacillary infection will be found, although the staphylococcus is not infrequently present. An examination of the deeper infiltrating serous fluid in-

variably shows the presence, rarely in pure culture, of the characteristic bacillus. In some of the fatal cases the infection rapidly travels up the limb and makes its emphysematous appearance in the tissues of the abdominal or chest wall. In certain cases involving the lower extremity the local tissue changes seemed to have been arrested at Poupart's ligament, although the blood was later found to be full of bacteria. In all fatal cases, the heart and larger blood-vessels of the body and brain were found to contain large numbers of gas bubbles. Aside from the septicæmic process, the presence of so much gas in the blood stream probably is the dominant factor in the almost sudden deaths to be noted in certain of the rapidly progressive fatal cases.

Under certain circumstances, the infective process becomes circumscribed to a varying extent. When this occurs it is thought to be largely due to the presence of a mixed infection, notably staphylococcus or pyocyaneus contamination. Aside from the surgical procedures which may have been instituted, it would seem that the occurrence, at an early stage, of these mixed infections may account for the protecting wall of leucocytes which forms and generally prevents an extension of the infective process. While tissue resistance undoubtedly plays a part in limiting or retarding the spread of this condition, the age and general vitality seem to have little, if any, influence in determining the outcome. The robust young patient, unless promptly and efficiently treated, falls as easy a victim as a less vigorous or older man.

Symptoms.—The signs of gas bacillus infection depend upon the pathological stage of the invasion. The symptoms which characterize the successive stages have a direct relation, first, to the character of the wound, as regards size, situation and degree of trauma; second, to the time elapsing between the reception of the injury and the institution of efficient surgical intervention; and, third, the care with which the after-treatment is conducted. Any one of these circumstances may not only have a decided influence on the progressive nature of the process, but is responsible in large measure for the intensity of the manifestations in the different stages and the virulence or activity of the infective organisms.

Gas bacillus infection, and the subsequent evolution of the respective stages, is almost necessarily confined to wounds of the extremities; for the reason that the same degree of trauma and deep destruction of tissue, which always precedes a spreading infection of this nature, would almost invariably prove quickly fatal if applied to any other part of the body, such as the head, neck, chest or abdomen. While mutilating wounds of the face, and large or small superficial wounds

elsewhere, may show the presence of *B. perfringens* at one time or another, nevertheless, the anaërobic and other general conditions for its favorable propagation or activity are usually lacking, and consequently there is very rarely an indication of an active invasion. For practically the same reason wounds of the hands rarely give evidence of the specific gas bacillus infection. Here the tissues are compact but not thick, so that there is relatively very little depth to the wound, and as a consequence aërobic, rather than anaërobic, conditions prevail. Deep wounds of the buttocks are especially prone to gas bacillus infection, and next, in the order of preference, is the thigh, leg, arm, forearm and foot.

Clinically, the first three *stages* of gas bacillus infection, namely, *injury, infection,* and *localized necrosis,* are grouped together for the reason that they are so inter-related, as regards the invasion, as to form practically a distinct entity with reference to the onset of symptoms, and these three stages represent the first clinical *grade* of gas bacillus infection. The reception of an injury, sufficiently severe to predispose to gas bacillus infection, is always accompanied at first by more or less shock, the degree of which depends upon the damage to the tissues and the attendant loss of blood. Either the infective organisms are driven into the wound with pieces of clothing or dirt, or else they invariably enter the wound after a very short time, and thus find in a deep wound, the character of which has already been indicated, the suitable media and anaërobic conditions upon which they thrive. The invasion of the organisms does not immediately become manifest, so that the first indications of a constitutional involvement, after reaction from the shock, would be the sapræmia due to the absorption of tissues but slightly removed from the normal, such as blood-clot or serum. Within a few hours after injury, the localized necrosis of the sides of the wound, though not apparent to the naked eye, would be present as the result of the severe traumatism inflicted upon the tissues in the path of the projectile. Although up to this point the specific activity of the gas bacillus cannot be demonstrated, it may be stated with certainty that by the time localized necrosis has become even microscopically manifest, the organism has begun its invasion.

The group of symptoms included under the general headings of shock, reaction from shock, and sapræmia are what might be called the prodromal symptoms of the invasion. The slight febrile manifestation of the sapræmia continues on into the slight fever which is due to the absorption of the newly-formed toxins of the infective organisms. Thus, in from ten to thirty hours after the injury, the mani-

festations of the specific invasion are apparent. These manifestations are a fever of one or two degrees accompanied by a rising pulse-rate, slight headache, malaise, anorexia and moderate thirst. If the part is splinted and protected the patient does not complain of pain at this time. At this early stage there is no apparent enlargement of the wounded part, although a scant serosanguinous discharge is present and, if carefully examined, will show the *B. perfringens*. The odor of the discharge at this time has begun to assume the characteristic fetid trait. Gas formation has also begun, although the characteristic "crackling" beneath the skin on palpation is rarely elicited at this time. Its presence in the tissues can be demonstrated by opening up the pockets in the depth of the wound which will cause the perceptible escape of a certain amount of gas. Ofttimes in shaving the part at this time, a slightly resonant note will be apparent, as if shaving over a tight membrane. A faint brownish discoloration will usually be seen in the skin immediately adjacent to the wound. The tension in the tissues of the limb would seem to be increased in that there is a slight resistance imparted to the fingers during palpation. Some of these symptoms appear later than others, but, as a rule, within forty-eight hours, and usually much less, all the manifestations indicated are present.

It is during this early part of the invasion that the abortive treatment gives excellent results. Usually up to twenty-four hours the invasion and the tissue changes are not so far advanced but that vigorous methods of wound sterilization can be successfully carried out. After this time the changes are more pronounced, although up to forty-eight hours the condition has usually not progressed to such an extent as to give evidence of the more serious stages. From about forty-eight hours on, the more or less rapid progress of the infection is in direct proportion to the lapse of time.

The second grade of gas bacillus infection is represented by the succeeding three stages already mentioned, namely, *progressive gas production, circulatory disturbance,* and *increased virulence.* These three stages are likewise grouped together on account of their clinical inter-relation. This grade of the infection begins to appear usually after about forty-eight hours, in the average run of untreated or inadequately treated cases. This grade extends usually from about forty-eight hours up to four, five or six days, dependent upon the size and condition of the wound, the severity of the infection, the general resistance of the patient, and the character of any previous surgical treatment. If the condition has not been thoroughly treated during the first grade, the manifestations of the second grade make their appear-

ance, as regards promptness and severity, in indirect proportion to the efficiency of the early surgical treatment. As the large base hospitals do not receive their patients until usually four or five days have elapsed, there is usually evidence in these cases of advanced second grade manifestations, because of the fact that the onset of this grade has occurred during the more or less prolonged journey to the hospital.

Not a little confusion has arisen, as regards the general description of what has been known as "gas gangrene." Some observers have described a condition which has been almost entirely unlike the experience of others. The reason that this occurs is due to the fact that different grades of the same condition have been described by different writers and the general process was not considered as a whole. The experience of a surgeon whose work has been comparatively near the front and where he has only had to deal with the first grade is at variance with the experience of another surgeon whose observations, in a base hospital further to the rear, deal entirely with the second or third grade of the infection. Hence it is that varying accounts of the same condition have appeared and given rise to doubt in the minds of many as to the exact nature of the process.

The onset of the second grade is usually characterized by a more or less pronounced increase in the pulse-rate, which appears to be out of all proportion to the temperature. The latter is at first only slightly raised, but, as the toxic products of the wound become more rapidly absorbed, the temperature begins to mount and may reach 104° or 105° F., in from ten to twenty hours. The discharge from the wound is now frankly and characteristically fetid. If a mixed infection has occurred, which is usually the case, the thin serosanguinous discharge is augmented by the presence of pus. The progressive elaboration of gas, which has already begun, can now usually be detected by the crepitation or "crackling" in the tissues when the latter are palpated. The brownish mottling or discoloration of the skin near the wound is much more distinct than in the first grade and shows a tendency to spread. The swelling of the part is now distinctly apparent and the tissues in the neighborhood of the wound are slightly indurated, showing decided evidence of circulatory disturbance. Acute pain in the wound is now complained of, and it is not unusual for a severe pain to manifest itself in the lumbar region. The headache, anorexia, malaise and restlessness are marked, and the facial expression assumes a dull, stupid character. These symptoms are all of a progressive character, lasting over a variable period of from one to three days, and this progressive nature of the symptoms indicates the *increased*

virulency of the infective process. During this time, or possibly a few hours later, small successive crops of vesicles begin to appear on the skin adjacent to the wound and may increase in size and number. When the symptoms of the second grade are well advanced, unless prompt measures are instituted, the patient begins to sink into a fitful coma-like condition which heralds the approach of the third and final grade, which is septicæmia.

The insidious onset of the third or *septicæmic grade* is characterized by a deepening of the stupor which has begun to make its appearance during the latter part of the second grade. There is now usually a rapid display of grave manifestations, which characterize an overwhelming infection and the invasion of the blood-stream by the infective organism. The ominous sign of a falling temperature with a rising pulse-rate makes its appearance. The apathetic stupor, the shallow and jerky respirations, the loss of body temperature, the rapid and thready pulse, all bespeak the approaching end. Occasionally, in those cases that linger for a longer period, there is a typhoid-like manifestation which is characterized by a whispering delirium, the so-called "coma vigil," carphologia, a transient half awakening or feeble restlessness, and a steady decline of both heart and respiration. In some cases death occurs within a very short period after the onset of the third grade. Sometimes within an hour the patient will rapidly sink and suddenly expire. This latter suggests the lethal presence of another overwhelming factor besides the septicæmia. As already indicated, this may be attributed to the rapid liberation of a large amount of gas in the blood-stream.

Diagnosis.—The diagnosis of gas bacillus infection resolves itself into a recognition of the progressive nature of the process. In view of the fact that it is almost certain that every wound in the present trench warfare which shows the slightest sign of infection is contaminated by the presence of the gas bacillus, practically every open wound under the present conditions must be regarded from the very beginning as potentially a gas bacillus infection. The only exceptions to this rule are those perforating bullet wounds which do so little tissue damage that they usually heal spontaneously. Even these wounds are not to be regarded too lightly, but must be treated expectantly for at least three days, as there is no immunity in any wound inflicted under the present war conditions. As already indicated, infection in some form is universal in every open wound of the present trench warfare, as statistics will show; and while the *B. perfringens* does not proclaim its presence in a certain percentage of these cases, nevertheless, a careful bacteriologi-

cal examination of the discharge is invariably positive. Under these circumstances a clinical diagnosis of the first grade of gas bacillus infection cannot be said to be demonstrable in every case of early infection that shows the latent presence of the gas bacillus. While the surgical treatment takes into consideration its more than probable future activity, yet a diagnosis of the first grade is tentatively withheld until there is evidence of the progressive manifestations already indicated.

It is true that other infections, which are improperly treated, show certain signs of progression; nevertheless, the progressive nature of these infections presents a different picture to the indications of gas bacillus infection. The latter infection is not only progressive at a much earlier period than any other known forms of wound infection, but its steady progress is characterized by an accentuation of certain features which are peculiar to gas infection, namely, the *localized necrosis,* the almost characteristic *odor* and the slight *skin discoloration.* In addition to this, the thin serosanguinous discharge manifests itself within a few hours after active gas bacillus infection, in response to the activity of the organism and its toxin in the depth of the wound; while in the usual forms of other wound infections the characteristic discharge or pus is not evident for a much longer period. The rising pulse-rate which is usually out of proportion to the degree of fever, while by no means pathognomonic of the first grade of gas bacillus infection, nevertheless is highly suggestive in view of the usual febrile response to other wound infections in which the rapidity of the pulse is usually in direct proportion to the degree of fever.

The diagnosis of the second grade of gas bacillus infection presents no real difficulties in view of the progressive nature of the process. Here, the cardinal signs of beginning gas bacillus infection, namely, the *necrosis, odor* and *skin discoloration,* are all accentuated. In addition, there is the usual crepitation in the tissues, as a result of the *progressive gas formation;* the swelling and slight local induration, to indicate *circulatory disturbance,* and the usual sharp rise of temperature, in connection with the increased pain and other minor symptoms, to indicate an *increased virulence* of the infection. Since a mixed infection is usually present by the time the second grade is reached, a consideration of this complication, when present, shows a thick yellow or greenish pus, which latter has a bluish tinge in case the contaminating organism is *B. pyocyaneus.* There is usually the further evidence of a more decided reaction in the tissues, as indicated by the more or less œdema. The behavior of the temperature would be somewhat different in that

the rise would generally be gradual from the date of the mixed infection, instead of spasmodically high as is the usual result of an increased virulence on the part of the gas bacillus. In view of a sudden rise in the temperature, pneumonia or pleurisy must not be overlooked and, once thought of, can easily be confirmed or excluded.

As regards the diagnosis of the third grade of gas bacillus infection, there is no essential difference between this grade and the septicæmia caused by the presence of pyogenic cocci in the blood-stream. It may be said that gas bacillus septicæmia appears to be somewhat more progressively asthenic in character than other forms, and that it is apparently complicated at times by the presence of an excess of gas in the blood-stream.

Prognosis.—The prognosis of gas bacillus infection, like other factors considered in describing this condition, has to be regarded from the view-point of the progressive nature of the process. The three progressive grades of this condition present a progressively grave outlook as regards the conservation of tissues and the restoration of health. While the grouping of the progressive stages into three successive grades is a somewhat arbitrary, although decidedly convenient, division of the process; nevertheless, it is also justified and thoroughly warranted by the clinical behavior as a whole. Like other infectious processes, there is of necessity a continuity between the subdivisions which represent the individual clinical aspects of the condition, and, by the same token, it must be remembered that there is no sharp line of demarcation between the three grades. For this reason, in order to arrive at a correct understanding of the clinical outlook of the three grades, it will be necessary to consider the separate, though hyphenated, stages which constitute the process as a whole. In order to emphasize the clinical aspects of this condition, and the grouping of the stages into grades, attention is invited to the following tabulated arrangement which shows the grades subdivided into the successive stages.

First Grade	Second Grade
1. Injury.	1. Progressive gas production.
2. Infection.	2. Circulatory disturbance.
3. Localized necrosis.	3. Increased virulence.

Third Grade

Septicæmia.

The first stage, that of injury, has a direct bearing on the future progress of the infection. If the wound is large, ragged and deep it affords the ideal condition for quick infection and rapid dissemination. The situation of the wound also influences the nature of the process.

If the wound, by reason of its anatomical location, has injured one or more large blood-vessels and nerves, the nutrition of the part is proportionately quickly embarrassed and the rapid death of the entire member may ensue. Under these circumstances, the massive death of the tissues as a whole, known as gangrene and usually of the moist variety, is substituted for the classical progressive localized necrosis which characterizes a purely gas bacillus infection. On the other hand, if the wound, though deep and ragged, has not injured the important nutritive and trophic tissue elements, its subsequent relation to the infective process depends upon certain selective localities. As already indicated, the buttock seems to be more quickly and universally susceptible to gas bacillus infection than any other part of the body. Next in importance would be the deep, narrow and destructive wounds of the thigh. The same character of wounds in the leg would seem to follow as a selective sequence, while a destructive wound of the arm or forearm comes next in the order mentioned. Although certain other localities, already mentioned, have been known to exhibit signs of gas bacillus invasion, yet on account of the thinness of the structures involved it rarely manifests itself. The degree of traumatism, as a prognostic factor, is partially considered above, but, on account of the known preference of the gas bacillus for pulpified and subsequently necrotic tissue, this factor, as regards the rapid progress of the infection, is in direct proportion to the local devitalizing extent of the traumatic process.

The next feature of prognosis as regards the injury is the time elapsing between the reception of the injury and the institution of efficient surgical procedures. The longer the wounded remain without thorough surgical attention, the more certain will the infective process become firmly and progressively established. As Carrel has said, the general fate of the wounded is dependent upon the quickness with which they can be transported to hospitals where adequate attention is provided. The thoroughness of the surgical intervention is also a weighty factor in the progress of the infection. Haphazard and inadequate measures are responsible not only for a false sense of security in regard to controlling the progress of the infection, but also culpably involved in the serious and ofttimes fatal delay in the proper treatment of the wound, resulting from a lack of thorough surgical technic at a time when the process could be more certainly controlled. Once that thorough surgical measures have been instituted, the next factor, as regards the future welfare of the injury, is the care with which the after-treatment is conducted. Unless painstaking thoroughness charac-

terize the after-treatment not only is the process prolonged, thus subjecting the patient to the dangers which not infrequently arise from various complicating influences, but the ultimate result, as regards bone and other tissues healing, will be proportionately unsatisfactory.

The influence of the second stage, or stage of incipient *infection,* on the general prognosis of the process is likewise largely dependent on the promptness with which the wound can be thoroughly treated. The longer the delay, the greater the opportunity for the infection to spread and become more virulent. Prompt and efficient measures at this time will largely limit and ofttimes abort the specific process, and at the same time not infrequently prevent a mixed infection. As regards the latter, while it frequently occurs sooner or later under the usual conditions of war surgery, it always prolongs the general process and invariably vitiates the ultimate result. The longer it can be prevented, the healthier the wound will become; and the consequent increased tissue resistance causes a more favorable outlook, as regards throwing off any contaminating process, and thus establishing a more satisfactory convalescence. While a mixed infection does appear to indirectly limit to some extent the spread of gas bacillus infection by causing the usual protective wall of leucocytes to appear, nevertheless, it is a condition to be avoided, not only for the reasons already given, but because there are other and much better means of controlling the spread of the specific process.

The third stage, or *localized necrosis,* completes the first grade of the general process for the reason that all the conditions are now ripe for the specific organism to inaugurate its vicious circle and augment its virulency. The earlier the necrotic wall of the wound can be removed, the speedier the cessation of the infective process. The amount of necrotic material in the wound necessarily exerts a potent influence, and the larger the amount of necrosis present the more radical must the procedures be in order to overcome the tenacity of the infection. The first grade of the general process presents on the whole a decidedly hopeful prognosis in the light of our present knowledge. The bacteriological and pathological conditions being known, it is only necessary to put into practice the principles of treatment which are known to be effective in establishing as near as practicable a return to the normal. It is during this grade, before the organism has gained a firm foothold and increased its virulence, that the abortive treatment offers considerable hope of bringing about a rapid and uncomplicated convalescence.

The outlook for the second grade of the process is decidedly less hopeful in its general character than the first grade. This establish-

ment of the second grade means that the gas bacillus, not unusually accompanied by a contaminating organism, is now more or less firmly implanted in the tissues of the wound and has begun in earnest the operation of its vicious circle. While somewhat dependent upon the degree of thoroughness in treating the infection during the first grade, the prognosis of the second grade depends largely upon the degree of progression in the three individual stages which make up the second grade. The first of these stages, which is *progressive gas production,* indicates that the principal clinical by-product of the infection, and the one which gives to the process its name, is being manufactured under circumstances progressively favorable to the progress of the process. The rapid evolution of the gas in the tissues predisposes the latter to a more rapid dissemination of the infection, in that it stretches the tissues and opens up new avenues for an extension of the process. It sometimes happens that the gas is so confined in the tissues, by reason of being pocketed, and the tension is so increased, as to cause a distinct explosive sound when the pocket is incised or the dressings removed, if the latter has acted as a plug in the wound. Hence it is, the more rapid the evolution of the gas, the more rapid are the changes which follow closely upon this stage, and therefore the more unfavorable the outlook.

The second stage of this grade, namely, *circulatory disturbance,* is an important factor in the prognosis in that its manifestations are usually apparent to the unaided eye and thus afford a quick and reliable index as to the general condition of the underlying tissues. A circulatory disturbance means that the nutrition of the part is being hampered and that another link is being progressively forged which will increase the activity of the process. The indications of this disturbance have already been mentioned. The parts in the neighborhood of the wound become distinctly swollen and there is a slight indurated œdematous condition apparent in the tissues adjacent to the wound. These manifestations indicate that the circulatory system is struggling to overcome the unsatisfactory nutrition of the part caused partly by the devitalizing influence of the increased amount of toxin in the tissues, and partly by the increased tissue tension due to the spread of the process. While the copper-colored mottling of the skin in the neighborhood of the wound is more or less apparent from the very first grade of the process, nevertheless, this discoloration, being now influenced by the progressive circulatory disturbance, assumes a more decided brownish tint, which might be described as a brawny induration, and there is distinct evidence of its decided tendency to spread. This

tendency of the discoloration to spread is in direct proportion to the extent of the circulatory disturbance, therefore the greater the disturbance, the more extensive the discoloration. This brawny discoloration can usually be easily detected and, when its progressive character is manifest, the gravity of the general prognosis is increased in proportion.

The third, or *increased virulence stage,* represents the climax of the second grade of the process. Its manifestations are closely associated with, and dependent upon, the preceding stage of circulatory disturbance. The progressive devitalization of the part, beginning with the localized necrosis in the walls of the wound, has now reached its culmination in the more extensive local death of the surrounding tissues. Once the resistance of these surrounding tissues is completely overcome, the rapid extension of the devitalization is assured and a fulminating character is imparted to the process. Besides the clinical evidence already mentioned, the increased virulence of the infective process is evident from the suddenly more extensive activity of the process and its rapid dissemination throughout the dying tissues. Hence it is that the massive death, which is now progressively occurring in the tissues surrounding the wound, has received the name of "gas gangrene." The most potent and continuous influence in causing this gangrenous process is undoubtedly the toxin elaborated by the infective organism. This toxin is the pivot in the vicious circle by means of which necrosis follows the elaboration of the toxin and bacterial activity is increased by the necrosis. The production of gas is only an incidental by-product in the process, and hence the term "gas infection" should also be discarded in that it does not express the true nature of the process. In view of the progressive character of the infection and its ability to create the conditions favorable for continuance of the process, the term "progressive emphysematous necrosis" would more accurately express the character of the condition and at the same time indicate its most prominent clinical manifestations.

The prognosis of the third, or *septicæmic,* grade of the process is exceedingly grave. It represents such an overwhelming degree of infection that all protective barriers have been swept away and the systemic invasion by the organism has occurred. As in other septicæmias, this lethal process is progressively asthenic in character but it would seem to be specially so in this particular form, which would also seem to indicate a total breaking down of all resisting power. Under these circumstances it is not surprising that almost sudden

deaths occur which may be hastened by the embarrassing presence of an unusually large amount of gas in the blood-stream.

Treatment.—The line of treatment to be adopted for this condition is to be considered under three distinct headings, according to the indications which are usually apparent as regards the invasion of any infective process. Thus there would be the prophylactic, the abortive, and the curative procedures.

The prophylactic procedures, as regards this infection, would seem to resolve themselves into the precautions which are more or less familiar to all, and which are the usual precautions against wound infection. Under the present circumstances of the trench warfare in Europe it would seem to be well-nigh impossible to obviate an exceedingly high percentage of wound infection, and especially infection with the organism responsible for the *progressive emphysematous necrosis.* The reasons for this are not far to find. In the first place, the entire western European war area has undergone for many years an intensive process of cultivation which has resulted in the soil being saturated with fertilizers and caused it to be the medium par excellence for harboring the infective organism. Once the trenches are dug deep in this soil, there is no escape from the ever-present conditions which are favorable for infecting every wound. Soldiers are obliged to occupy these trenches for days and nights consecutively under all weather conditions, so that their clothing and body surface become more or less permeated with the trench dust and dirt, which latter, of course, contains the infective organism in concentrated numbers.

A consideration of these facts leads to the theoretical conclusion that something might be accomplished in a prophylactic way by not only covering the floor of the trench with small fagots of wood, which is now the universal custom, but to make an effort at the disinfection of the sides of the trench. Calcium hydrate, or slaked lime, white-washed thickly and repeatedly along the sides of the trench could at least do no harm and doubtless would be productive of not a little indirect good. Besides being very cheap and easy to acquire in large quantities, it is a deodorant and possesses distinct antiseptic properties.

The sides of the trenches are frequently lined by upright stakes interlaced with cross-wise pieces of thin wood in order to prevent the crumbling dirt from falling into the trenches. This arrangement would be more favorable for the application of the white-wash than when the sides of the trench are unprotected, although, under the latter circumstances, once the dirt is hard and dry it would be no great difficulty to keep a thick covering of lime on the trench walls. There could be

no military objection to this, as it would not be visible to the enemy under ordinary circumstances. Small sections of the trenches are covered over to some extent all along the line, and the positions of the opposing trenches are perfectly familiar to all combatants in the field, so that any added feature of trench hygiene, even though conspicuous, would not unduly expose the occupants to the enemy fire or cause enemy attention to be attracted any more than at present prevails. Cementing the wall of the trench has been done in selected places, but for a general application it is out of the question for many reasons.

There is something to be said about the clothing from a prophylactic stand-point. The French soldier's uniform and overcoat, which latter he wears continuously for some reason both winter and summer, is made of a thick, coarse, felty material which certainly becomes very easily more or less permanently contaminated with dirt. Body sweat and rain keep the clothing inundated for considerable periods, and this moisture in the fabric helps to maintain the vitality of any organisms which may be present in the dirt. The British soldier's uniform is composed of somewhat the same character of material, resembling a rather thick flannel. It would certainly be the part of wisdom, from the view-point of infection, to adopt a less porous and more easily cleansible type of uniform, such as khaki cloth which has a hard finish. In addition to the foregoing, cleanly habits and a rigorous policing of all trenches would of course be productive of general good.

The soldier should receive, as a necessary part of military training, repeated instructions in the rudiments of asepsis, antisepsis and the conditions favorable to wound infection. This would unquestionably not only lead to a more careful and intelligent application of the first-aid package, but would be conducive of far-reaching good as regards improving and avoiding the conditions favorable to infection. At the first-aid stations iodine should be freely used, pouring it into the wound and applying it to the surrounding surface. Carrel recommends the injection of Dakin's fluid into narrow wounds at this time and also dressing the large wounds with gauze saturated with the same solution.

The abortive treatment of this progressive infection contemplates being able to thoroughly treat the wound within twelve hours after the receipt of the injury. The earlier this treatment is begun, the better the outlook for accomplishing its purpose. The principles of this abortive treatment are twofold, mechanical and chemical. The mechanical process calls for the prompt and delicate removal of all foreign bodies, such as projectiles, fragments of clothing and unattached splinters of bone. It is necessary, in the vast majority of cases, to enlarge

the wound in order to thoroughly accomplish this important feature of the work. The X-ray is a valuable adjunct and should always be used when practicable. There should be as little traumatizing of the wound as is consistent with thorough surgical technic. All overhanging and ragged edges should be carefully trimmed and the wound should be thoroughly inspected to ascertain the presence of loose, ragged or apparently devitalized tissue. Pieces of fascia should be carefully removed and the sides of the wound left as smooth as possible. All bleeding should be thoroughly controlled at this time and the general extent of the damage ascertained.

The chemical part of the abortive treatment calls for the continuous application of an antiseptic which will not only promptly destroy the organisms with which it comes in contact, but which will dissolve or detach any pieces or areas of devitalized or necrotic tissue which happen to be left behind or develop afterwards in the wound. The Dakin fluid is such an antiseptic, and is not only highly germicidal but is practically non-irritative. As regards large wounds, the thorough application of this fluid is accomplished first by the introduction into the depth of the wound of long fenestrated narrow rubber tubes, the number depending on the size of the wound and the diverticula present. The object is to so place the tube or tubes that when fluid is injected through them and into the wound it will reach all parts. With the tubes in place, and projecting for four or five inches outside the wound, the latter is now lightly packed with gauze saturated with the Dakin fluid. Alcohol should not be used in conjunction with the Dakin fluid, as it causes the latter antiseptic to become irritative to the tissues by the rapid liberation of free chlorine. A layer of non-absorbent cotton, through which pass the rubber tubes, completes the dressing. The fluid is injected every one to two hours into the tubes or the latter may be coupled to a Murphy drip apparatus. The object is to keep the gauze in the wound thoroughly saturated with the fluid, but not cause it to leak from the wound. This is kept up sometimes for as long as forty-eight hours, depending upon the size and character of the wound. At the end of this time if the treatment has been thoroughly carried out, the wound will be sterilized in the great majority of cases. The wound is inspected and the dressings carefully renewed every morning.

In addition to the sterilization of the wound the abortive treatment also contemplates the use of some form of permanent dressing or an apparatus best suited to the special needs of the individual case. In case of a fractured bone the use of a carefully applied plaster dressing, either in the form of a fenestrated permanent cast or as a moulded

splint, is recommended. Plaster is advocated for the reason that, as soon as the sterilization of the wound is assured, the patient can be transported to the rear much more easily and safely in this form of splint than in others. When the large hospital of the interior is reached the cast may be removed if thought necessary, and any form of special apparatus applied that will best suit the individual needs of the case. As regards the patient's transfer to another hospital, no case should be transported, except in an emergency, until the sterilization of the wound is complete. It has often occurred that the delays incident to prolonged travel have resulted disastrously for the patient when there is an active infection in the wound.

It has been the practice with a large number of surgeons, as regards the early general treatment of wounds, to open up the latter thoroughly; remove foreign bodies; irrigate with salt solution or an antiseptic; introduce drainage tubes; and either use a dry or wet dressing, according to the individual preference of the surgeon. Whether or not the surgical indications have always been conscientiously carried out, it is a fact that a very large number of wounds reach the base hospitals of the interior in a septic condition. This indicates that the early and subsequent treatment has not been thorough enough to prevent a continuance of the infection. The abortive treatment outlined above has been successfully used a large number of times, and there is every reason to believe that, when conscientiously applied, it will greatly improve the statistics of wound infection. It must not be lost sight of that in the abortive or any other line of treatment, one of the cardinal surgical indications is to produce aërobic conditions in the wound instead of anaërobic, which latter is the condition most suitable for a continuance of the infective process.

The curative treatment has especially to do with the second grade of the infective process, and it is this grade of the condition that has been usually treated in the large base hospitals of the interior for the reasons already given. This form of treatment either calls for a continuation of the treatment already instituted elsewhere, or the adoption of special procedures to meet any special demands. In the beginning, this treatment may be an intensified continuation of the abortive treatment outlined above, or it may take the form of any special surgical procedure individually preferred by the surgeon. The X-ray should always be made use of as a matter of routine to ascertain if any metal has escaped being removed in the previous treatment. It is usually a foreign body, either metal, cloth or bone, which is responsible for keeping up the infection in the earlier stages of the second grade. In

any case the wound should be thoroughly inspected and all pockets or diverticula opened up. Any necrotic material should be carefully trimmed away at this time and especially should necrotic or loose fascia be sought for. As this class of cases usually presents a mixed infection, it is more than likely that drainage tubes will have to be used to facilitate the drainage of pus. These tubes need not interfere with the use of the Dakin fluid as outlined above. Some operators may prefer to adopt a different line of treatment than the Carrel method, in which case it may take the form of any well-recognized surgical procedure. Dr. Wineberg, of the Pasteur Institute, has introduced a serum which has been tried out in a large number of different cases but so far no apparent results have followed its use.

After the case has been operated upon, the general and local conditions must be carefully watched. If the infection is being controlled, and improvement sets in, the temperature and pulse subside, the discharge becomes progressively less, the wound gradually assumes a healthy appearance and a satisfactory convalescence is established. If, on the other hand, the condition not only does not improve but shows indications of becoming progressively worse, certain radical measures must be contemplated with the idea of at least saving the patient's life. If the process involves the upper or lower extremity, amputation may be performed as a life-saving measure. This must not be undertaken too lightly, nor be too long delayed to reasonably insure saving the patient

Sir Almroth Wright has recommended the placing of strips of gauze in the depth of the wound and in special incisions which are made with a view to reaching the deep fascial planes. These strips of gauze are kept more or less continuously saturated with salt solution, and the presence of the latter in the wound causes a certain amount of responsive outpouring of serum from the tissues. This treatment has been used with apparent success by a number of British surgeons and at the Japanese Red Cross Hospital. While this method of treatment may be satisfactorily used in selective cases, it is the opinion of quite a large number of surgeons, who have had considerable experience during the present war, that the great majority of progressive cases require a more radical treatment; such as not only a thorough opening up of the wound, but also the more or less continuous use of an active antiseptic.

Another method of treatment, which was enthusiastically endorsed by a few, consisted in the subcutaneous introduction of oxygen under pressure into the tissues above the wound. This method was reported as being in successful operation at a certain few hospitals, but it has been thoroughly tried out a number of times in other hospitals and the

reports have been almost invariably to the effect that the procedure exerted very little influence, if any, upon the infective process.

The indications for amputation are largely a matter of surgical judgment and experience. A number of factors would have to be considered before arriving at a definite conclusion as regards the entire removal of a limb. It is during the latter part of the second grade of the progressive process, namely, during the stages of circulatory disturbance and increased virulence, that amputation comes up for serious consideration. It is because of the rapid local and constitutional changes at this period that the surgeon must be on his guard and prepared to act promptly in case a decision is reached. Familiarity with the pathology of the last two stages of the second grade of the process will alone enable the surgeon to form an intelligent opinion as regards the radical removal of the offending member. Consideration must be given not only to the local tissue changes, as manifested in the stage of circulatory disturbance, but the constitutional resistance must be carefully estimated at the stage of increased virulence. As already indicated, these two last stages of the second grade are so closely inter-related, and the process as a whole is so dependent upon the mutual and responsive reactions occurring between these two stages at this time, that the climax or crisis represents the culmination of the more or less rapid general changes which have taken place as the result of this intimate relationship between the two stages. The index of the critical point in the patient's condition is therefore the point where the local and constitutional manifestations have converged to form a picture of combined and acute distress.

Under these circumstances, the local manifestations which would call for removing the part would be the more or less rapid display of progressive tissue death, as indicated by the spreading discoloration, the increased œdematous induration and the manifest inability of the embarrassed circulation to reëstablish itself in the swollen and tense member. At this time there would be a perceptible loss of temperature in the tissues below the wound and no appreciable evidence of a distal pulse or circulation.

The serious constitutional manifestations which follow closely the above local changes and which indicate an *increased virulence,* are those which show unmistakable evidence that the infective process is gaining a more or less rapid ascendency over the body resistance. The temperature at first would begin its spasmodic or steady rise, the already disproportionately rapid pulse would further increase in rate, and the

patient would exhibit the dull and listless attitude towards his environment which shows the influence of a powerful depression.

In view of the combined evidence of a beginning progressive local and constitutional decline, the surgeon is thoroughly warranted in deciding upon an amputation. The latter must be performed with the utmost despatch, consistent with the recognized principles of good surgery. The stump should be left wide open and no effort made to limit the size of the wound by the introduction of sutures. This latter admonition is highly important in view of the paramount necessity of making sure that aërobic conditions will prevail in the wound.

In order to save as much of the limb as possible it will ofttimes be necessary to disregard the formation of skin-flaps on account of the position of the wound or the area involved in the necrotic process. At other times, a certain amount of skin may be available as a flap covering without sacrificing the length of the limb. In either case, the wound is to remain completely open during the course of the after-treatment, and the skin, if left to itself, will gradually retract and eventually necessitate a second operation to secure a painless and useful stump covering.

In order to prevent, or limit as far as possible, the skin retraction in these wounds, a method was devised which constantly pulled upon the skin during the period of after-treatment. This method proved to be highly successful in quite a number of these cases and is recommended on account of its simplicity and effectiveness. It consists of gluing a wide piece of canton flannel material to the skin, about two inches above the edge of the wound and with the " hairy " side of the material next to the skin. Sewn to this wide piece of canton flannel are four narrower pieces of the same material, two inches apart, and having a short piece of narrow webbing attached to each of the four pieces, as shown in Fig. 11.

This apparatus is not used until three or four days have elapsed after the operation so that nothing may interfere with keeping the wound wide open. Although a certain amount of sloughing takes place in these cases, it quickly clears up under wet antiseptic dressings and, after three or four days, it is safe to apply the apparatus.

It not infrequently happened that previously amputated cases, in which the wound had been left open, were admitted at the American Ambulance. These cases, some of them several weeks old, were also successfully treated with the skin-traction apparatus.

When the wound is to be dressed, the extension straps are laid back and do not interfere with this procedure. Narrow strips of rubber tissue, placed cross-wise, cover the raw surface and over this is placed

FIG. 1.—A fatal case of gas bacillus infection in a perforating bullet wound of the right leg, resulting in a compound comminuted fracture of both bones, showing the characteristic discoloration, slight swelling and typical cluster of blebs. Patient received at hospital six days after injury and an immediate amputation performed at middle third of thigh. There was no injury to the anterior tibial artery.

FIG. 2.—Fatal case of gas bacillus infection of the arm and forearm, following a high explosive shell wound of upper arm. Patient received five days after injury and an immediate amputation performed at shoulder-joint.

FIG. 3.—Showing a gas bacillus infection of a mutilating shoulder wound, due to a high explosive shell fragment, and accompanied by necrotic infiltration of a large part of the chest wall which proved fatal. The patient was received five days after injury and the necrotic material was removed, followed by a continuous irrigation. (By courtesy of the Harvard Unit.)

FIG. 4.—A case of first grade gas bacillus infection, the result of a bullet wound, involving a slight splintering of the iliac crest. Patient was received three days after injury, the onset being less rapidly progressive than the usual ragged shell wounds. Note the slight brownish discoloration in the skin adjacent to the wounds.

FIG. 5.—Showing the method of trench construction and the conditions under which wounds become infected.

FIG. 6.—Showing an amputation stump of a case of progressive emphysematous necrosis (gas bacillus infection) with the apparatus applied for pulling upon the skin. This amputation was performed during the latter part of the second grade of the progressive process. The black staining shown upon the skin of the stump was caused by the silver nitrate solution used as a moist dressing.

FIG. 7.—Showing the complete dressing and apparatus for skin traction in position in the same case as Fig. 6.

FIG. 8.—The same as Fig. 7, showing the improvement in skin growth over the stump at the end of two weeks.

FIG. 9.—Showing another second grade amputation after two weeks' use of the skin traction apparatus. In this case it was permissible to allow a certain amount of skin flap at the time of operation, although no sutures were used and the wound was treated openly throughout.

FIG. 10.—Showing an old amputation case under treatment with the skin traction apparatus. This case improved steadily and, after one month, a minor plastic operation completed the cure.

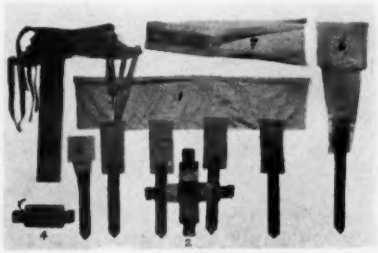


FIG. 11.—Showing the pattern of the canton flannel extension straps used for the purposes already mentioned. The material used was a medium-weight canton flannel. 1, the broad piece with extension straps, used for the skin traction apparatus; 2, the wooden cross-piece to which the above extension straps are buckled; 3, cloth, with webbing extension, which is glued to the forearm in the overhead extension treatment of compound fractures of the humerus; 4, wooden traction piece to which the foregoing webbing is buckled; 5, cloth anklet used to obtain extension on the foot in cases where the wound in the leg was low down or involved the ankle-joint; the horizontal piece is secured over the dressing around the ankle, while the vertical piece turns under the plantar surface and is afterward pinned to the horizontal piece; 6, cloth extension strap used with the Blake splint; 7, a double extension cloth, the ends of which are glued to the leg, used as a substitute for adhesive plaster in the application of a Buck's extension.

the wide gauze pads which are then secured in place by a narrow strip of gauze surrounding the dressings at the end of the stump. The extension straps are now brought over the end of the stump and the webbing is buckled to corresponding webbing on a cross-piece of wood. The latter has attached to it a cord, which passes over a pulley, attached to an upright at the foot of the bed, and secured to a bag containing five to seven pounds of weight. In order to make sure that the dressing will not slip off the wound, two long narrow strips of gauze are secured cross-wise over the dressing and pinned to the wide piece of canton flannel which is glued to the skin, the strips of narrow gauze passing through the intervals between the extension straps. In order to make a better pinning surface for the strips of gauze, it was necessary to apply five or six turns of a wide gauze bandage snugly over the broad piece of canton flannel glued to the skin. This arrangement was kept up usually for about a month, the dressings being renewed daily, and by that time the skin had usually come down over the stump to such an extent as to be able to dispense with the apparatus entirely.

The preparation used to glue the canton flannel to the skin for the traction apparatus, also to glue the extension straps to the leg in the application of the Blake splint, and to glue the extension straps to the forearm in the overhead extension treatment of compound fractures of the humerus, is as follows:

Resin
Alcohol, of each ..... 50 parts
Benzine ..... 25 parts
Venice turpentine ..... 5 parts

NOTE.—Powder resin; add half of the alcohol; add all of the Venice turpentine with the benzine, and then wash the measure with the remainder of the alcohol.

As regards the treatment of the third or septicæmic grade of *progressive emphysematous necrosis,* there is practically nothing that can be done to ward off a fatal result. Rectal salt solution with adrenalin chloride, slowly introduced, will aid other stimulants in prolonging life; while blankets and hot-water bottles will prevent the rapid lowering of body temperature. The serum treatment, and all other measures that have been tried, have signally failed when once the septicæmic grade has begun. The only hope offered is to prevent the onset of the third grade by prompt amputation in the latter part of the second grade and before the patient is too weak to stand the shock of operation.

THE SIGNIFICANCE OF FOREIGN BODIES IN THE TISSUES*

By Walton Martin, M.D.
of New York
surgeon to st. luke's hospital

My attention has been drawn to this subject by the very different significance of foreign bodies as a complication of gunshot injuries in modern warfare and as seen in civil practice. It has seemed to me of interest to gather together what we know of foreign bodies in the tissues with and without infection. I have used the word tissue to include all parts of the body excepting the cavities lined by mucous membrane and the surfaces covered by epithelium. I have not considered foreign bodies in the œsophagus, stomach, intestines and bladder, that very strange and curious chapter of surgery.

There are two sources of information regarding the behavior of the tissues in the presence of foreign bodies. First, there is a large amount of experimental work, as the subject has always been of interest from the stand-point of general surgery; for not only are large amounts of foreign material introduced as ligatures and suture material, and in plates for holding fractures, but also the attempt has been made to replace tissue defects by foreign substances—for example, the introduction of artificial corneas, plates for skull defects, paraffin for correcting deformities, etc. The subject is also one of great interest to the general pathologist as a means of throwing light on the complex questions of inflammation and new tissue formations.

The second source of information is furnished by clinical reports of cases in which foreign bodies have been accidentally embedded in the tissues.

I shall first review some of the well-known facts about the tissue reaction to foreign materials when no infection is present. Soft and absorbable foreign substances are gradually dissolved and taken up by the tissue cells. Compact and insoluble foreign bodies are shut in by new-formed tissue, which is slowly transformed into a fibrillar connective-tissue capsule, gradually shutting the foreign body off from contiguity with the organism. If the foreign body is hollow or porous, the new tissue grows into it and separates it from the rest of the tissue on the inner as well as the outer surface.

There are no foreign materials in the strict sense absolutely chem-

* Read before the New York Surgical Society, October 13, 1915.

ically and physically indifferent to the tissues. The very presence of the foreign body implies an alteration in nutrition and a damage to the tissue caused by the dislodgement of cells to make place for the foreign body.

Very finely divided particles, such as the pigment introduced in tattooing, or other substances in powdered form are partly taken up by the leucocytes and carried away, and partly remain *in situ* and may be recognized in the tissue spaces between the connective-tissue bundles and in the connective-tissue cells. The pigment also finds its way into the lymph-stream and may be found in the neighboring lymphatics. In tattooing the arm, the axillary lymph-glands are found loaded with pigment. When large masses of powder are introduced, however, a process of encapsulation of the entire mass takes place.

The most characteristic cells in the reaction caused by the presence of all but the finest particles of foreign material are the so-called foreign-body giant-cells with many nuclei arranged near the periphery. The cells are of frequent occurrence in the cicatricial tissue following surgical operations, forming in the immediate neighborhood of threads of cotton, minute particles of gauze, insoluble suture material, and after injury in which small particles of foreign material have been introduced. They are interesting because the microscopical findings so closely resemble tuberculous tissue. These cells obviously possess the property of attacking and dissolving foreign substances.

Size, shape, weight, and consistency are apparently of slight significance when the body is at rest, in relation to the surrounding tissue, but motion of the body in the tissue, especially if it be pointed or have an irregular surface, causes a marked reaction. Under these conditions, a capsule containing fluid is formed, the organism apparently reacting to the repeated trauma of contact with rough or pointed bodies, by surrounding them with fluid. Such cysts, produced by the trauma of a foreign body, have frequently been observed experimentally. They contain a pinkish, sterile serum.

The effect of motion in setting up irritation has often been observed clinically. It is especially frequent about small foreign bodies in the fingers. Kummer [12] removed a cyst the size of a pea, formed about a fragment of needle which had been embedded in the finger for three years. The little cyst was pear-shaped; the stem of the pear was formed by part of the needle closely surrounded by tissue. The other end of the needle projected into a small bulbous cavity. The part of the needle closely surrounded by tissue was eroded and thinned; the part that projected into the cyst was of the original size and appearance.

At times, pointed foreign bodies, such as needles, seem to have a tendency to be pushed through the tissues, the pointed end piercing the tissues during certain muscular actions. There are numerous clinical observations and pathological anatomical autopsy findings that prove without doubt this travelling of foreign bodies in the tissues. Some years ago I cut down on a needle in the palm of the hand, shown in that position distinctly by an X-ray photograph the day before. After a long search I was unable to find the needle. It was then shown by a fluoroscopic examination to be beneath the annular ligament, and from this position, about four inches above the point where it was first observed, it was readily removed. Such experiences are not uncommon.

Aside from the movement of pointed foreign bodies, there have been a few reports of embolic transference of projectiles.

Schloffer[24] (1903), in a paper on this subject, reported experiments on rabbits in which he had introduced shot into the inferior vena cava. At autopsy, the shot was found in the pulmonary arteries. He also reported four cases, two of his own, and two from the reports of others. Rubesch[23] showed in Prague, on March 8, 1912, a patient whose history is very interesting. He was a man twenty-eight years old, who, in an attempt at suicide, shot himself over the heart. The weapon used was a 7 mm. revolver, of old construction and poor quality. The wound of entrance was about 1.5 cm. inside the left mammary line, and 5 cm. above the nipple. There was no wound of exit. He was taken to the hospital and the next morning, after recovering from the preliminary shock, his only complaint was a severe pain in the right leg. The pulse in the right and left femoral was the same. The pulse in the right dorsalis pedis could hardly be felt. The right leg felt cool. X-ray examination showed no projectile in the thorax. Examination of the right leg, however, showed the bullet in the position of the right femoral artery. Two days later, after provisional ligation of the external iliac, the right femoral was exposed and the bullet was felt within the vessel. The vessel wall was incised and the bullet, which was tightly wedged in the lumen, was removed. It lay with its long axis corresponding to the long axis of the vessel, and its base directed centrally. It weighed 2.85 grammes. Centrally and peripherally to the bullet were thrombi. The clots were removed and the vessels were sutured with paraffin silk. The operation was followed by gangrene of the leg, making necessary an amputation through the lower part of the thigh.

A critical examination of this and the other reported cases seems to prove beyond question the possibility of the transference in the blood-stream of small projectiles of low initial velocity, the bullet passing in a very short time from its point of entrance, over the heart or one of the great blood-vessels, to be lodged, like an embolus, in one of the arteries.

The capsules found about foreign bodies vary according to their chemical characteristics. Bodies not chemically active seem to find

lodgement in the tissue with astonishingly little reaction. The capsule is very simple and is made up of fibrillar connective tissue. The tissue cells lie in close contact with the foreign body. Bodies like celluloid, glass, hard rubber, quartz, etc., readily heal in the tissue provided they are not movable in relation to the surrounding tissue. Salzer, in one instance, succeeded in embedding an artificial cornea which remained *in situ* for two and a half years. Von Eiselsberg [18] reported a case in which he had replaced a defect of the sternum, following resection for tuberculosis, with a celluloid plate. The plate was covered by a skin-flap. After four and a half years, this foreign body was still firmly in place in the tissue, and the skin was freely movable over it.

In bodies of greater chemical activity, more irritation is caused in the tissues. The capsule is not so simple; about copper, for example, there are three layers recognizable. First, in immediate contact with the foreign body is a layer made up of cell detritus and dead material, then a layer of spongy connective tissue, and, finally, a layer—the one farthest from the foreign body and in immediate contact with the rest of the organism—made up of fibrillar connective tissue. The capsule about iron is loaded with pigment cells, having staining properties which suggest their identity with ferratin. The appearance is analogous to that seen in the absorption of inorganic iron from the intestinal tract (Bayer).[2] The capsule about silver is very simple and the silver seems little acted upon by the tissue cells. Aluminum seems to occupy an intermediate position between silver and copper. The five metals, silver, aluminum, brass, iron and copper, can be arranged in this order according to the irritation they create in the tissues. The capsule in many instances is lined by a layer of cells which suggest epithelium. By suitable stains, however, the cells can be demonstrated to be modified connective-tissue cells.

Years ago, Nussbaum [21] (1853), in his studies on artificial corneas, introduced small spheres of glass, iron, wood and copper under the skin in his own body, and noted the difference in the amount of irritation produced. Glass provoked almost no reaction, copper, on the other hand, caused so much that he was compelled to remove the stitches on the second day.

The different tissues seem to react very differently to the same foreign body. Leber (1891) made an interesting observation in this connection. He found that copper would heal in the crystalline lens almost without reaction, yet caused severe pathological changes when introduced into the vitreous or anterior chamber. Shortly afterward, Wagenmann [27] reported a case which offered clinical confirmation of

this point. By the explosion of a percussion cap, a small fragment became embedded in the crystalline lens of a boy ten years old. Twenty-seven years later Wagenmann removed the lens for cataract and found a small fragment of copper embedded in it. Until two years before the operation the lens had been clear and the eyesight, excepting at one point, good. The eye had been repeatedly examined.

Barth [4] observed strands of catgut unabsorbed, although thinned and eroded, in parenchyma of the kidney after seven months, but found them completely absorbed in the fibrous capsule.

In the muscular and connective tissues there are many examples of foreign bodies which have remained without reaction for years. In the heart muscle bullets and other foreign bodies have frequently been reported. Within the last five years, Bailey,[3] Chandler,[5] Kunreuther,[25] Leporski,[25] Magnagnon,[25] Northrup,[22] Sternberg,[25] Zesas [25] have all reported cases. I give in full the autopsy findings taken from the case of Huppert [10] (1876). He found at autopsy a needle embedded in the posterior part of the left ventricular wall. The end projected into the ventricular cavity. The pointed end was covered over by a dull yellowish-white tissue, smooth like the rest of the endocardium, and under the microscope it appeared lined by elongated four-sided flat cells. The underlying portion was made up of fibrillar connective tissue. From the history, the needle had been in the tissues for five years. The heart valves and the heart muscle were normal. During life there had been no signs of cardiac irregularity.

The part of heart wall occupied by the foreign body is of importance. In certain situations, the irritation caused by it, according to the well-known experience of physiology, produces irregularity in the heart beats, pain, etc. The chief danger seems to be at the time of entrance of the foreign body. Marked disturbances may also be caused by its extraction.

In the brain there are also a great number of observations of embedded bullets. I have shown this evening a man, fifty-five years old, who was shot in the head thirty years ago. The X-ray plate shows the bullet in his brain. Dr. LeWald has kindly also shown the plate of a second case in which the bullet has remained in the brain for fifteen years. A copy of this plate is in Lagard's [17] book on gunshot injuries.

In bone, bullets and other foreign substances heal readily. There is usually a connective-tissue capsule immediately about the foreign body, and then a layer, more or less marked, of sclerotic bone. In some instances there is no connective-tissue capsule, the foreign body lying in immediate contact with bony tissue. In avascular cartilage there is

no capsule, the foreign material often lying almost reactionless in its bed.

There is a curious observation by Bayer[2] regarding the behavior of copper in joints. He oxidized copper wire and introduced it into the knee-joint, and into muscle, tendons and periosteum. After two days, all the pieces of copper were examined. All except those in the knee-joint had the dark color of copper oxide. The pieces in the joint had lost their dark color and had the shiny appearance of metallic copper. He attributes this to the reducing action of the synovia. There is no statement as to whether or not the joint was kept at rest.

There have been many observations on these chemical changes that occur after bodies have been lodged in the tissues. I think every one who has removed a needle which has been for some time in the tissues has been impressed by its coal-black appearance, often shown in sharp contrast to the tissues, especially if they have been made bloodless by the application of an Esmarch bandage. Iron, lead, and copper all undergo chemical alterations when in contact with body fluids,—by oxidation and the formation of metallic salts, especially carbonates and chlorides (Marchand).[18]

Lewin (1911)[16] has advanced the view that lead, which has remained for years undissolved in the tissue, may undergo chemical change into soluble lead salts, be absorbed, and produce toxæmia. He points out that the surface of a projectile is relatively small, and that greater opportunity for chemical action would be offered if the bullet were broken up or if small shot were introduced. That the clinical signs of lead poisoning are so rarely seen he attributes to the fact that the symptoms of lead intoxication are so easily overlooked or falsely interpreted. But that the bullet can set up severe toxic manifestation he offers several interesting observations.

In 1892 Lewin had reported a case with Kuster which brought the matter to his attention. A soldier had been wounded at the battle of Mars la Tour, August 16, 1870. The wound of entrance was over the head of the tibia; there was no wound of exit. He was discharged cured in October. The bullet was not extracted during his treatment. He remained well until 1888, except for occasional joint pains. He then began to present the symptoms of lead poisoning, anæmia, weakness, colic, lead line on the gums and trembling of the hand. At operation there were scattered areas of blue-black stains in the head of the tibia, and the neighboring connective tissue and knee-joint. These areas were removed and the patient recovered from the symptoms of lead poisoning. The chemical examination by Lewin of the fragments showed the presence of lead oxide, hydroxide and carbonate.

It was apparently a case of fragmentation of a lead bullet, with chemical change of the fragments of the metal into soluble leads with absorption and poisoning.

It would seem from the very common occurrence of lead bullets in the tissues and the extraordinary rarity of the symptoms of lead intoxication that Lewin's views should be accepted with caution. He has collected the reports of seven cases since 1892.

There is abundant evidence, then, that bullets, needles, in fact all manner of foreign bodies, can remain for years in the tissues, encapsulated, shut off from the organism and causing no irritations, or, in very rare instances, perhaps giving evidence by a general toxæmia of their slow dissolution; but all these facts are based on the supposition that no pathogenic micro-organisms have been introduced at the same time, or, if they have been introduced, that they have been either destroyed or made innocuous by the body cells. The behavior of the tissue in the presence of infected foreign bodies is very different. One of the oldest surgical principles, as well known as the relief offered by the opening of an abscess, is that a suppurating sinus leading to a foreign body will close if the foreign body is removed. So wide-spread is this knowledge that to the layman to this day the extraction of bullets is the *sine qua non* in the treatment of gunshot wounds.

A study of the reaction of the tissues to infected foreign bodies is of great interest.

If a small number of organisms of low virulence are introduced with the foreign body, it is possible for the embedded foreign body to heal in the tissues, the organisms being destroyed by the bactericidal properties of the tissue. It is also well known that bacteria can be shut up in the tissue and rendered harmless and yet years afterward through some lowering of tissue resistance take on pathogenic properties.

Two years ago I operated on a circumscribed bone abscess of the tibia. It was surrounded on all sides by dense sclerotic bone. The pus from the abscess contained a pure culture of typhoid bacilli. The man had had typhoid fever forty years before. The micro-organisms had apparently been living in his tissues for years, shut in, encapsulated, innocuous. Through some accident, possibly trauma, the balance between living tissue cells and living micro-organisms was upset and the latter took on pathogenic activity. In the same way there are numerous instances of foreign bodies remaining for years in the tissues without reaction, and then causing signs of local inflammation.

Years after all the great wars, there have been instances of this character. A soldier ran a piece of glass the size of a small coin into the sole of his foot. It remained there twelve years. He could stand and march without feeling pain. At the end of this time suppuration was set up around the foreign body (Weitz).[6] It is not difficult to

imagine that lowered tissue resistance, or injury of the connective-tissue capsule may afford an opportunity for the imprisoned dormant micro-organisms to start growing. Possibly the tissues about the foreign body may be a point of least resistance suitable for the lodgement and growth of pathogenic bacteria which have entered the body. Harland (1878)[11] removed a projectile from the palm of the hand. The bullet had been there fifty-nine years. The patient was eighty-three years old; he had been wounded at Waterloo, and had done heavy work as a gardener and laborer. A similar experience is not uncommon in bodies embedded as a deliberate surgical procedure. Foreign substances, introduced to correct deformities or to fill defects, heal in the tissue, often with evidence of considerable tissue reaction, and then after a period of weeks, months, or even years, show the signs of local suppuration, necessitating incision and subsequent removal of the foreign body to close the sinus which inevitably follows.

Aside from organisms introduced in small quantities or of low virulence giving rise to what may be termed resting or latent infections, there is the vastly more important question of the introduction of foreign material and micro-organisms in sufficient numbers and of sufficient virulence to set up infections, and the question of the unfavorable influence exerted by these foreign bodies on the progress of the infection.

Since Pasteur's[26] communication in 1878 in which he told how sheep allowed to graze in a meadow sprinkled with a virulent anthrax culture rarely died of the disease, yet perished in numbers when prickly plants which could wound the mouth, pharynx and tongue were added to the fodder, the relations between solution of surface continuity, injury and infection have been well recognized. There is no sounder surgical principle than that mechanical violence predisposes to infection. The introduction of a foreign body is a form of traumatism, there must always be damage to the tissue by death and dislodgement of cells to make place for the foreign body. Finely divided foreign bodies, introduced experimentally into the peritoneum or pleura, aid to a very marked degree the activity of the micro-organism inserted at the same time. Each foreign particle forms a focus favorable to the growth of micro-organisms. They appear to make it difficult for the protective forces of the tissue to act. The normal outcome, if the bacteria do not overwhelm the organism, seems to be toward the extrusion of the foreign body.

The majority of gunshot injuries in the present war are complicated by infected foreign bodies. Fragments of shell casing and irregular

shrapnel balls carry with them into the contused and lacerated tissue, surface dirt, hair, clothing and all manner of small foreign bodies. The rifle bullet of high initial velocity carries with it, in wounds of parts of the body covered with clothing, threads and fragments along the bullet tract and forces them into the tissues. The dangerous nature of particles of clothing was long ago pointed out.

Fischer[8] (1882) writes, "When one thinks of the shocking condition of the clothing of soldiers in the field, one can easily imagine the danger of carrying fragments into the wound." Particles of clothing found with the bullet are of common occurrence in gunshot wounds occurring in civil practice. Eight years ago[19] I reported before this Society a case of gunshot wound of the stomach. The bullet passed through the abdominal wall, the anterior and posterior wall of the stomach, the diaphragm, pleura, and lodged in the muscles of the back. The stomach wounds were closed and the pleura drained a few hours after the injury. Three weeks later I removed from the back the bullet and pieces of clothing which were lying in a small abscess containing 2 drachms of pus. The injury was inflicted with a 32 calibre revolver. But the significance of the clothing is not the same in such cases.

Fontin and Karlinski[14] found virulent staphylococci, streptococci, B. coli communis on fragments of old, well-worn uniforms. Experiments done with the German mantled bullet with high initial velocity have shown that particles of clothing are carried into the bullet tract, and that some of these particles are even forced into the healthy surrounding tissue. The old-time projectile of lower initial velocity has no such effect. It has also been shown experimentally that it is impossible to disinfect these bullet tracts either with chemicals or the thermocautery.[20]

Koller,[15] seventeen years ago, concluded an article on experiments on the Treatment of Infected Gunshot Wounds, with the statement that he agreed with Bruns in strongly combating the idea that every gunshot wound must be treated as an aseptic wound and covered with an occlusive dressing. The majority of gunshot wounds, on the contrary, did not belong to this category. It was only true of the lighter grades of bullet injuries.

Particles of dirt, threads of clothing and other small foreign bodies also adhere to the rough surface of fragments of shell casing, to detached bullet mantles, to pieces of shrapnel, so that the question so often discussed as to how often the bullet itself is a source of infection hardly comes under discussion. Not only are foreign bodies particles infected but they are carried, each with its modicum of infection, into lacerated, contused and detached tissues. Projectiles striking bone

communicate to the shattered fragments their own force, and each particle, itself a minute projectile, is hurled through the tissues. Even when the projectile has passed out of the body it is often astonishing to see the number of fragments of clothing, etc., that can be removed from even a superficial seton wound by drawing through the wound tract a piece of knotted sterilized gauze. It would be difficult to arrange experimentally better conditions for infection, especially when one considers the imperfect immobilization after the injury is received and the lowering of general body resistance from pain, hemorrhage, loss of sleep, exposure, all inevitable before the patient can reach a base hospital.

Besides the pyogenic organisms, many others, ordinarily saprophytic, are carried with them on foreign bodies into the tissues and often take on pathogenic properties. These are the conditions which have been a chief factor in giving rise to the dictum now going about among the surgeons in Europe—" War surgery is not peace surgery." These are the conditions which account for that curious, heavy, sickening odor caused by great numbers of suppurating wounds, which one notices in all the large war hospitals. Large incisions properly placed for drainage, removal of detritus, detached fragments of bone and tissue and all accessible foreign bodies, flushing of wounds with peroxide as means of cleansing mechanically, the bubbling of the solution loosening up minute fragments of foreign material and enabling them to be washed away, has become the routine treatment for the severe wounds.

I have wished to draw this sharp contrast between what we know of foreign bodies introduced into the tissue with the least possible trauma, and with as little infection as possible, and the foreign bodies introduced with enormous trauma and often with much infection. The foreign body has a very different significance when introduced through comparatively clean skin and clothing, with low initial velocity, and receiving immediate care, and introduced as we have described and seen it under the condition of modern warfare.

The significance of a resting uninfected foreign body imbedded in the tissue is simply mechanical; it may demand removal from pressure on a nerve or from interference with function.

The significance of an infected foreign body is twofold; it is a focus of infection, from the micro-organisms carried with it into the tissues, and at the same time it exerts an unfavorable influence on the protective forces of the tissues. Its removal takes away a source of infection and is one of the means of aiding the body cells to resist the growth and spread of pathogenic bacteria.

BIBLIOGRAPHY

[1] Aschoff, L.: Pathologische Anatomie, vol. i, p. 610.

[2] Bayer, H.: Einheilung von Fremdkörpern (full bibliography). B. Z. Kl. Chir., 58, 1908; Münchener Medizinische Wochenschrift, 1909, p. 2416.

[3] Bailey, C. H.: A Case of Foreign Body in the Heart. Arch. of Internal Medicine, vol. xi, 1913.

[4] Barth: Nierenbefund nach Nephrectomie. Arch. f. klin. Chir., vol. lxiv, sec. 2, 1893.

[5] Chandler: Heart in Which a Needle Was Found Embedded in the Intraventricular Septum. British Medical Journal, April 22, 1911.

[6] Doran, A.: On Certain Foreign Bodies Embedded in the Tissues Without Producing Inflammatory Symptoms. St. Bartholomew's Hospital Rep., xii, London, 1876.

Fraenkel: Foreign Body in Heart. Münchener Medizinische Wochenschrift, 1914, p. 1201.

[8] Fischer: Handbuch der Kriegschirurgie, 1882.

[9] Gussenbauer: Die Traumatischen Verletzungen. Deutsche Chirurgie, Lief. 15, 1880, Chap. III.

[10] Huppert, M.: Eine Nähnadel im Lebenden Herzen. Arch. der Heilkunde, 19 Jahrg., 1878, p. 517.

[11] Harland: British Medical Journal, 1878, p. 788.

[12] Kummer: Kyste développé autour d'une aiguille. Revue de Chir., 1891, N. 7.

[13] Kirschner: Paraffin Injectionen in Menschlichen Gewebe. Virch. Arch., Bd. 182, H. 3, 1905.

[14] Karlinski: Centralb. f. Bakt., 1 Abt., vol. xviii, 1895.

[15] Koller, F.: Experimentelle Versuche uber die Therapie inficirter Schusswunden (full bibliography). Deutsch. Zeitschrift für Chirurgie, vol. xlvii, 1897–1898, p. 211.

[16] Lewin, L.: Das toxische verhalten von Metallischen blei und besonders von Bleigeschossen in tierischen Körpern. Vol. xciv, 1911.

[17] Lagard: Gunshot Injuries. New York Medical Journal, October 22, 1892, p. 164.

[18] Marchand, F.: Der Process der Wundheilung, Deutsche Chirurgie, Lief. 16, 1901, Chap. xxvi, p. 353. Die Einheilung der Fremdkörper (full bibliography).

[19] Martin, W.: Lesions Associated with Gunshot Wounds of the Stomach. Annals of Surgery, vol. xlv, 1907, p. 699.

[20] Müller, A.: Experimentelle Untersuchungen über die Infection von Kaninchen durch Geschosse. Deutsche Zeitschr. f. Chir., vol. xlvii, p. 199.

[21] Nussbaum, J. N.: Deutsche Klinik, No. 34, August 20, 1853.

[22] Northrup, W. P.: Needle in Left Ventricle of Heart. Pediatrics, vol. xxv, No. 7, 1913.

[23] Rubesch, R.: Ein Beitrage zur Embolischen Verschleppung von Projectelen. B. Z. kl. Chir., vol. lxxx, 1912.

[24] Schloffer, H.: Neben Embolische Verschleppung von Projectelen. B. Z. kl. Chir., vol. xxxvii, February, 1903, p. 698.

[25] Thorel, Ch.: Pathologie der Kreislauforgane des Menschen (bibliography). Ergebn. der Allgemeinen Pathologie, vol. xvii, 1915, p. 692.

[26] Vallery-Radot: La Vie de Pasteur, p. 407.

[27] Wagenmann: Beitrag zur Kenntnis der Zündhütchenverletzungen des Auges. Arch. f. Ophth., 44, 1897.

PRIMARY NEOPLASMS OF THE LYMPHATIC GLANDS INCLUDING HODGKIN'S DISEASE*

By William B. Coley, M.D.
of New York

This paper is an attempt to add some further clinical data bearing upon primary tumors of the lymphatic glands, on the basis of a study of 167 cases personally observed.

I scarcely need state that this group of neoplasms gives the most hopeless prognosis of any in the entire field of malignant tumors—hopeless not only from the stand-point of surgery, but also as regards X-ray and radium treatment.

I should like to discuss the clinical diagnosis of neoplasms of the lymphatic glands if time and space permitted. I can merely say that while in many cases it is possible to make a correct diagnosis from clinical signs alone, together with the history of the case, rapidity of growth, and blood examinations, in most cases a positive early diagnosis cannot be made without a microscopic examination, and not always then. I do not believe there is much risk in an exploratory operation for the removal of enough tissue for a microscopic examination. In many of these cases the tumor is made up of a considerable number of more or less discrete glands, and one small gland can be taken out with little risk of producing generalization of the disease.

The almost hopeless prognosis of the disease has been emphasized by the paper of Fabian [1] based upon the results of treatment in a large series of cases collected by him. "Operation," he emphatically declares, "can come into consideration only in such cases in which the site of the disease is isolated, a thing which it is often difficult to prove. It is furthermore necessary to exclude leukæmia and pseudoleukæmia by quantitative and qualitative blood analysis, tuberculosis by Pirquet's and lues by a Wassermann reaction." He further holds that, in view of the extreme difficulty in making an early definite diagnosis, it is essential to do an exploratory incision for the purpose of microscopic examination which in the majority of cases enables one to differentiate between lymphosarcoma and Hodgkin's disease. "Clinically," he states, "these two conditions may be deceptively similar, a circumstance which would not be of great importance were the treatment of the two lesions the same. This, however, is not the case. Operation,

* Read in abstract before the American Surgical Association, June, 1915.

[1] Münchener med. Wochenschr., August 26, 1913, No. 34, 1876.

according to our present knowledge, is contra-indicated in cases of malignant lymphoma even if localized in character, numerous observations having shown that in these cases, as in leukæmia and pseudo-leukæmia, the most thorough excision often does not check the progress of the disease, but, on the contrary, causes more rapid proliferation."

"On the basis of the collected experience up to the present time," Fabian states, "we must admit that surgical treatment in general has been most discouraging." He cites the exhaustive compilation of Dufhus, in 1895, comprising 22 cases of lymphosarcoma of the neck and axilla observed at the Greifswald Clinic. Of these 3 were inoperable; 3 of the remaining 19 were operated upon by exploratory incision only; 6 of the cases treated by radical operation had a speedy recurrence; 9 left the clinic well but in 4 of these a recurrence was soon observed; 1 patient was operated upon four times. No permanent cures are mentioned.

The number of cases in which the appearance of the sarcoma in the cervical glands is preceded by an attack of tonsillitis or sore throat, points very strongly to an infectious origin. One of the cases in my series, which I have given in some detail, also points very strongly toward an extrinsic and infectious origin other than through the tonsil. In this case the patient cut her finger on a vase; a swelling in the axillary gland on the same side almost immediately appeared and developed into a rapidly growing sarcoma. Of course, in this case it is not possible to prove the causative connection between the prick of the finger and the sarcoma; the latter may have been merely a coincidence, still, in connection with the cervical cases following an infection in the tonsil, it is certainly suggestive.

There is much evidence pointing to a very close relationship between the groups of tumors at present designated as malignant tumors —sarcoma and carcinoma—and the group regarded as Hodgkin's disease. Indirect evidence of this close relationship is suggested by the recently published experimental work of Dr. Maud Slye, of Chicago, covering a period of ten years. She found that cancer was apparently hereditary in mice, and was able to produce a breed of mice in which practically every member of the family died of cancer. Aside from the question of heredity, which is irrelevant to the topic under discussion, she found that all the different types of malignant disease were produced in these cancer families, one having carcinoma, another sarcoma, another epithelioma, and still others, Hodgkin's disease and lymphatic leukæmia. Furthermore, these latter conditions she has never observed except in cancer families.

To turn for the moment to the histological features in these different

tumors of the lymphatic glands, we find there is great difference of opinion in characterizing the histological structures.

In one of my cases, a tumor of the axillary glands was pronounced, in the original report, lymphosarcoma, and the same pathologist two years later described it as an endothelioma. Other specimens were pronounced round-celled sarcoma by one pathologist and Hodgkin's disease by another. This is a common observation. Not infrequently have I received the following opinion:

"The tumor is certainly malignant, but whether sarcoma or carcinoma, I am uncertain." The term "embryonal carcinoma," much used of late, is being more and more frequently employed to describe some of these border-line cases. Herein lies the great significance of the study of primary neoplasms of the lymphatic glands. This study leads one to pay less and less heed to the finer histological distinctions, the "judicial niceties" of the microscopic examination in these cases—the interpretation of which is by no means clear—but rather to group the cases according to certain well-defined clinical features. Thus we have a group of the so-called Hodgkin's type of tumors, or neoplasms of the lymphatic glands, with fairly distinct clinical features, sufficiently characteristic in the ordinary case to make the diagnosis comparatively easy, namely:

1. Enlarged glands, usually beginning (in the cervical region) on the one side, and soon involving those on the other side; freely movable; more or less discrete, skin not attached; moderately firm in consistence but not fluctuating, gradually followed by involvement of the axillary and inguinal glands, and not infrequently the spleen and liver; a blood picture which Bunting and Yates believe to be peculiarly characteristic; a more or less rapid deterioration in general health, uniformly ending in death.

2. The ordinary type of round-celled sarcoma of the cervical glands, beginning as a single nodule, softer in consistence and more apt to infiltrate the surrounding tissue than in the Hodgkin's type; may extend to the glands on the opposite side, but this is not usual in the early stages; more rapid increase in size, and more frequently associated with pain; running a much more rapid course than the ordinary Hodgkin's and only infrequently causing general metastasis. It resembles Hodgkin's in the fatal prognosis. The differential diagnosis of this type of tumor from tuberculosis is not usually difficult, owing to its very rapid progress without any tendency to become caseous.

Then we have a third group of cases designated ordinarily as lymphatic leukæmia, which differs from the Hodgkin's very little except in the blood picture. I believe it is possible to regard this group of cases

as closely allied to Hodgkin's, and perhaps as a different stage of the same disease. A uniformly hopeless prognosis is common to each of these different groups.

THE TREATMENT OF PRIMARY SARCOMA OF THE LYMPHATIC GLANDS

If the disease is discovered before more than a single gland has become involved, it should be removed by surgical operation and the patient put upon a prolonged course of treatment with the mixed toxins of erysipelas and Bacillus prodigiosus in the hope of preventing a recurrence.

If the disease is primary in the tonsil, and is discovered before the surrounding tissues have become markedly infiltrated, and before metastases have taken place in the glands of the neck, the tonsil should be removed, and if the diagnosis is confirmed by microscopic examination, similar prophylactic toxin treatment should be instituted.

One of the most remarkable cases of an apparent cure is that in which a large tumor, a round-celled sarcoma, of the tonsil and cervical glands disappeared under seven weeks' treatment with the mixed toxins of erysipelas and Bacillus prodigiosus, and the patient remained well for nearly seven years, when a similar trouble developed in the opposite tonsil and neck, and rapidly recurred after two operations. Following the recurrence after the second operation the mixed toxins were used for a short time with apparently little effect. The patient died two months later. Here it is fair to believe that the original tumor was completely cured and that the one in the opposite side was an entirely new development, not a recurrence of the original tumor.

In many cases it is almost certain that operation, particularly incomplete operation, greatly increases the malignancy of the tumor and causes it to grow more rapidly than before. Hence, I believe that "palliative operations," or partial operations, in this class of cases are contra-indicated.

In view of the importance of establishing, beyond question, the correctness of the diagnosis, I believe that a portion of tissue, preferably a small isolated gland, sufficiently large to permit of microscopic examination, should be removed; this can be done in most cases without any material risk in the way of causing metastasis or increasing the malignancy of the growth.

The prognosis after X-ray treatment in these cases is not infrequently good as regards immediate result; but, as Fabian states, and my own experience confirms, there have been no permanent cures from the X-rays in this group of cases. The same is true of radium.

HODGKIN'S DISEASE

Assuming the correctness of the view which I have long held that Hodgkin's disease is a type of sarcoma closely related etiologically, I believe the same treatment should be applied to Hodgkin's disease as to sarcoma of the lymphatic glands.

If the disease is discovered in the early stages, when only one or a few glands are involved, most extensive and radical removal, if possible, should be employed, always accompanied by enucleation of the tonsils, if enlarged, as they are the most probable source of primary infection.

Inasmuch as operation alone is practically always followed by a recurrence of the disease, any hope of a cure must depend upon post-operative treatment.

Yates and Bunting believe that long-continued X-ray treatment together with enucleation of the tonsil has apparently effected a cure in two cases, the patients having remained well upward of five years.

It should be noted that in both of these cases the disease was attacked while in the very early stages, both having been sons of physicians, and the disease was recognized comparatively early.

In one case, first treated in November, 1908, diagnosis confirmed by microscopic diagnosis, tonsillectomy was followed by X-ray treatment and hygienic measures. In this case there were only a few enlarged bilateral cervical and axillary glands, with no involvement of abdominal glands, spleen, or liver. In December, 1912, a few glands, smaller than peas, could be felt in the posterior triangle of the neck, but none in the groin. In January, 1914, six years after the beginning of the treatment, the patient was in excellent health; the blood picture was negative.

In the other case of Yates and Bunting, ten years of age, there was slight enlargement of the glands in the axillæ and groins; abdomen negative; blood picture positive Hodgkin's; axillary gland removed for diagnosis; pronounced Hodgkin's. In this case the disease was first noticed in December, 1909; in 1910, tonsillectomy, followed by X-ray and hygienic treatment. September, 1913: glandular condition about the same; a few slightly enlarged glands palpable. January 6, 1914: blood picture normal; glands quiescent. This patient was well at the last observation, made four years after the beginning of the treatment.

Nearly everyone has observed very marked beneficial effects following the use of the X-rays in Hodgkin's disease in almost all its stages; but aside from the cases observed by Bunting and Yates, I believe there is not a single case on record of a cure by this agent; nor do I consider it proper to regard the two cases cited in their series as positive cures.

It should be noted that in both of these cases they were dealing with an early stage of the disease, and there was no evidence of involvement of the spleen or liver, such as was present in my cases treated with the toxins.

My reasons for advocating the toxins in Hodgkin's disease are based upon the remarkable effects that I have observed in a number of such cases, particularly two in which entire disappearance of the lesions occurred.

The following two cases of Hodgkin's disease have been reported somewhat fully in my earlier papers:

CASE I.[2]—*Hodgkin's disease; clinical diagnosis confirmed by microscopic examination; entire disappearance of lymphatic and splenic enlargement under two months' treatment with mixed toxins of erysipelas and Bacillus prodigiosus, without other treatment.*

G. K., aged twenty-four years; family history negative. This patient felt so entirely well that he refused any further treatment and left the hospital. He gained forty pounds in weight and remained in good condition for about seven months. Shortly after, all of his former symptoms returned, and the disease progressed rapidly, causing death in about six months. This proves the correctness of the diagnosis.

The second case,[3] I believe to be so remarkable that I have decided to reproduce it in full.

CASE II.—*Advanced Hodgkin's disease successfully treated with the mixed toxins of erysipelas and Bacillus prodigiosus.*

The patient was treated, under my direction, by Dr. C. E. Preston, of Ottawa, Canada, one of my former house surgeons.

G. M., male, aged nineteen years, was admitted to the Ottawa Hospital May 4, 1908, with a history of glandular swelling beginning on one side of the neck and later involving both sides, of about one year's duration. There was gradual loss of weight and increasing anæmia. The glands of the neck were greatly enlarged; the spleen was enlarged and palpable three-fourths of an inch below the margin of the ribs; the liver extended three inches below the border of the ribs; inguinal glands were moderately enlarged. Weight, 122 pounds. The diagnosis of Hodg-

[2] Further Evidence in Support of the Theory that Hodgkin's Disease is a Type of Sarcoma. Transactions of the American Surg. Ass'n, 1908.

[3] A Report of Recent Cases of Inoperable Sarcoma Treated with Mixed Toxins of Erysipelas and Bacillus Prodigiosus. Cancer Research Society, Buffalo, April 12, 1912, and Surgery, Gynæcology and Obstetrics, August, 1911.

kin's disease was made by all of the attending physicians and surgeons of the hospital, and a hopeless prognosis was given.

The mixed toxins were begun June 1, the initial dose being one-fourth minim. This was gradually increased until July 10, when the maximum dose of twelve minims was reached. This caused a temperature of 103° and a rather severe chill. The treatment was continued for three months, partly by the family physician. Examination on January 1, 1909, showed the patient quite well, weight 145 pounds, with only a small gland in the right side of the neck. He had returned to his usual work. The toxins were discontinued.

Reëxamination on September 10, 1909, by the family physician, shows the patient in fine condition, all the glands have disappeared and he continues his hard work. Under date of April 6, 1911, Dr. Preston stated that he had just examined the patient and found him in perfect condition.

Under date of September 1, 1915, Dr. R. E. Webster, of the County Carleton General Hospital (Ottawa, Canada), writes that the patient at present is in perfect health (7 years later). Glandular system is apparently normal. He further adds that, while no glands were removed, the case was a typical one of Hodgkin's disease; all the glandular symptoms were present. The patient was treated from June 1 to July 30, 1908, at the Ottawa Hospital, after which the toxin treatment was carried on by the family physician at home.

In spite of the absence of a microscopic examination there can be little doubt that the diagnosis of Hodgkin's disease was correct.

All evidence of the disease disappeared under no other treatment than the toxins, and the patient has remained well for more than seven years after treatment. I believe this case comes nearer to being a permanent cure than any case thus far recorded.

The more important cases of my series are given in considerable detail in the Transactions of the American Surgical Association for 1915, to which the reader who may be specially interested in the subject is referred, the entire number being reported in tabular form at the end of this paper. Some of the cases have been previously reported in the *Transactions of the Third International Cancer Research Conference* (Brussels, 1913), but inasmuch as this volume can be found probably only in the larger libraries, and in order to make the paper complete, I have thought it wise to reproduce the histories of these cases either in full or in abstract, the most important feature being the addition of full data as to the subsequent progress in the cases that are still living.

The tables cover 167 cases of primary neoplasms of the lymphatic

glands, including Hodgkin's disease, personally observed within the last twenty years:

With regard to locality, the cases are distributed as follows:

76 cases of sarcoma of the neck.

24 cases of sarcoma of the tonsil and neck.

10 cases of sarcoma of the retroperitoneal and mesenteric glands.

17 cases of sarcoma of the inguinal glands.

18 neoplasms of the axillary glands (16 sarcomas, 2 carcinomas).

21 cases of Hodgkin's disease.

1 case of sarcoma of the mediastinal glands.

As regards the relative frequency of lymphosarcoma in the sexes, my tables show a great preponderance of males over females throughout the entire series, except in the mesenteric gland cases, in which the proportion is equal, *e.g.:*

Retroperitoneal and mesenteric glands, 10 cases (5 males and 5 females).

Axillary glands, 18 cases (10 males and 8 females).

Inguinal glands, 17 cases (12 males and 5 females).

Neck, 76 cases (54 males and 23 females).

Hodgkin's disease, 21 cases (16 males and 5 females).

Tonsil and neck, 24 cases (20 males and 4 females).

The duration of life in the fatal cases, so far as definite data are available, may be of some interest:

2 died within ten days.

12 died within a few weeks.

20 died within less than six months.

13 died within six months to one year.

11 died within one to two years.

5 died over two years after the onset of the disease.

A summary of the cases personally observed shows that 26 of the patients have been successfully treated—that is, the tumors (inoperable) entirely disappeared—with the mixed toxins of erysipelas and Bacillus prodigiosus, and have remained well from one to twenty-two years. Nineteen patients remained well from three to twenty-two years.

Of 76 cases of sarcoma of neck, 8 have remained well from two to fourteen years.

1 round-celled sarcoma of neck, well two years.

1 sarcoma of neck, well two years.

1 adenocarcinoma of neck, well three years, and then recurred (the primary tumor was pronounced sarcoma).

1 round-celled sarcoma of neck, well four years.

1 round-celled sarcoma of neck, well six years.

1 round-celled sarcoma of neck, well six and one-half years.

1 small round-celled sarcoma of neck, well thirteen years.

1 round-celled sarcoma of neck, well fourteen years.

Of 24 cases of sarcoma of tonsil and neck, five have remained well from one and one-half to nine and one-half years.

1 round-celled sarcoma, well one and one-half years.

1 round-celled sarcoma, well four and one-half years.

1 round-celled sarcoma, well six years.

1 spindle-celled sarcoma, well eight years.

1 round-celled sarcoma, well nine and one-half years.

Of 10 cases of sarcoma of the mesenteric and retroperitoneal glands, 4 have remained well from one to twelve years.

1 round-celled sarcoma, well one year.

1 round-celled sarcoma, well two years.

1 spindle-celled sarcoma, well two years.

1 spindle-celled sarcoma, well twelve years.

Of 17 cases of sarcoma of inguinal glands, 3 have remained well from four to seven years.

1 sarcoma, well four and a half years.

1 sarcoma, well four years.

1 small round-celled sarcoma, well seven years.

Of 18 cases of neoplasms primary in the axillary glands, 4 have remained well from three to nine years.

1 round-celled sarcoma, well three years.

1 round-celled sarcoma, well four years.

1 lymphosarcoma, well four years.

1 lymphosarcoma, well nine years.

One case of sarcoma of mediastinal glands has remained well six years.

Of 21 cases of Hodgkin's disease 1 remained well for seven months after complete disappearance of the disease under five weeks' toxin treatment. The patient refused further treatment and died of a recurrence one year later.

In the list of cases of other men (treated under my direction) one Hodgkin's case recovered, and remains well, at present, seven years later.

RECURRENCE AFTER APPARENT CURE WITH THE MIXED TOXINS

In a certain number of cases in which the tumor or tumors had entirely disappeared under the toxin treatment and the patients were apparently cured, the disease recurred at varying intervals from six months to six years. A study of these cases may be of some interest:

In one case, after a very large and rapidly growing primary neo-

plasm of the lymphatic glands had apparently entirely disappeared, the disease returned and progressed rapidly when the dose of the toxins was diminished, but began to decrease again and finally disappear under larger doses of the toxins. The patient is now well two years and a half.

In another case, a round-celled sarcoma of the tonsil with extensive metastases in the neck, the tumors entirely disappeared under six months' treatment with the mixed toxins; one and one-half years later a recurrence took place in the glands of the neck, which proved fatal within six months.

In a third case, a round-celled sarcoma of the tonsil and glands of the neck, the tumors having almost entirely disappeared under five weeks' toxin treatment, began to increase in size again when the dose was reduced. Under increased doses tumors completely disappeared. Six months later a recurrence took place which proved fatal within a year.

In another case still, a round-celled sarcoma of tonsil with extensive metastases in the neck, the disease entirely disappeared under eight weeks' toxin treatment. The patient remained well for six years, when a recurrence or a new tumor developed in the opposite tonsil; this tumor recurred very quickly after two operations and caused death within four months.

In one case, an intra-abdominal sarcoma primary in the mesenteric glands and small intestine, the disease entirely disappeared under four months' toxin treatment, then recurred one and one-half years later and proved fatal within six months.

In one case, an alveolar sarcoma, primary in the glands of the neck, the disease almost completely disappeared under four months' toxin treatment; the patient remained well for three years, when a recurrence took place; incomplete removal followed by the toxins and X-rays; patient well at present, six months later. In this case the tumor was pronounced adenocarcinoma by Dr. Ewing. December 1, 1915: There is evidence of mediastinal involvement.

Small round-celled sarcoma of the inguinal glands; complete disappearance under the toxins; recurrence, which again yielded to the toxins; the patient is well at present, seven years later.

In a recent case of recurrent inoperable sarcoma of the tonsil and neck, the tumors decreased to one-fourth their original size under six weeks' toxin treatment. Then the improvement ceased and the remaining tumor was removed by operation followed by toxin treatment which was kept up for about two months. The patient then left for a two weeks' vacation. Examination upon his return showed a recurrent tumor one inch in diameter at the site of the incision. He was again

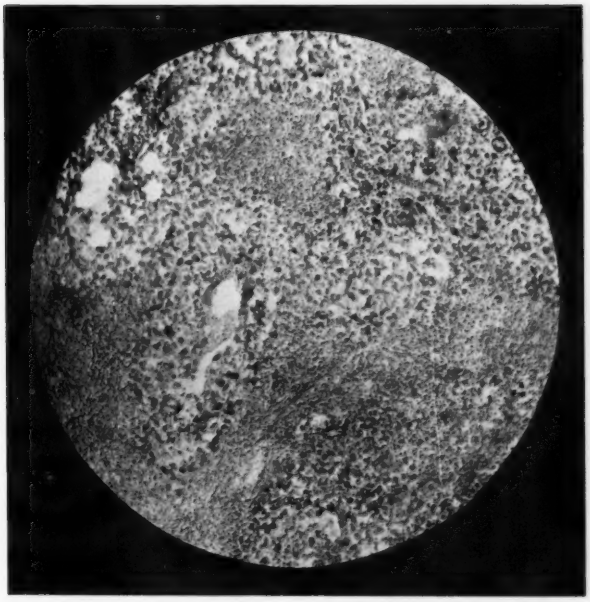


FIG. 1.—Case 21, Neck table. Lymphosarcoma of supraclavicular and retroperitoneal glands; very rapid progress. Patient died in three months.

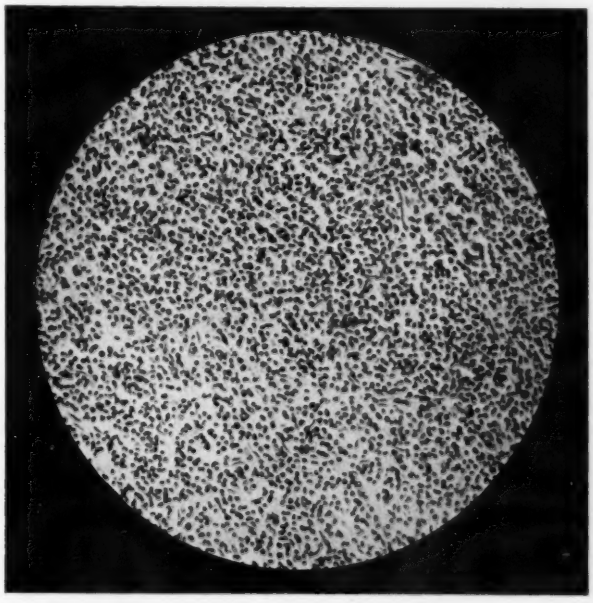


FIG. 2.—Hodgkin's disease; rapid course.

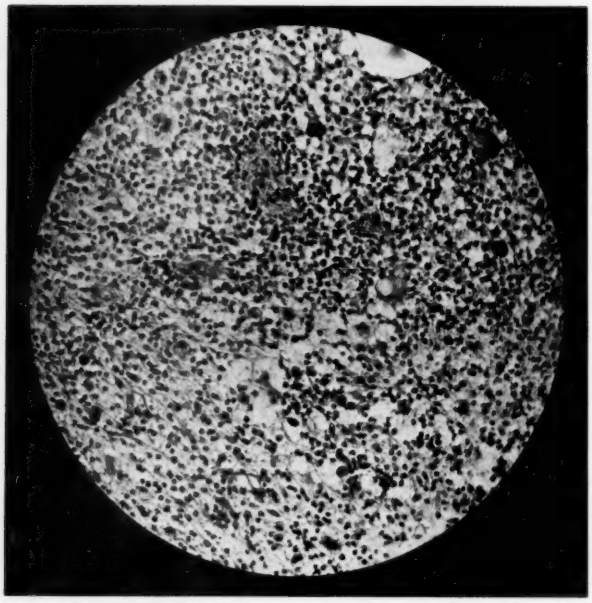


FIG. 3.—Clinical diagnosis was sarcoma of neck. Microscopical diagnosis was Hodgkin's disease.

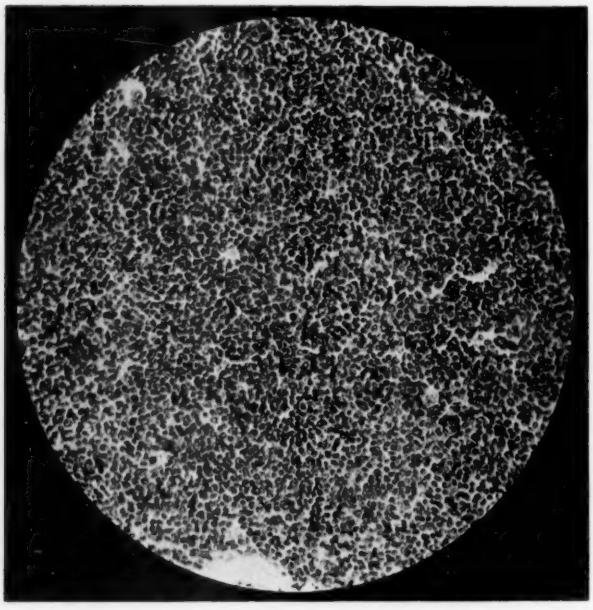


FIG. 4.—Hodgkin's disease.

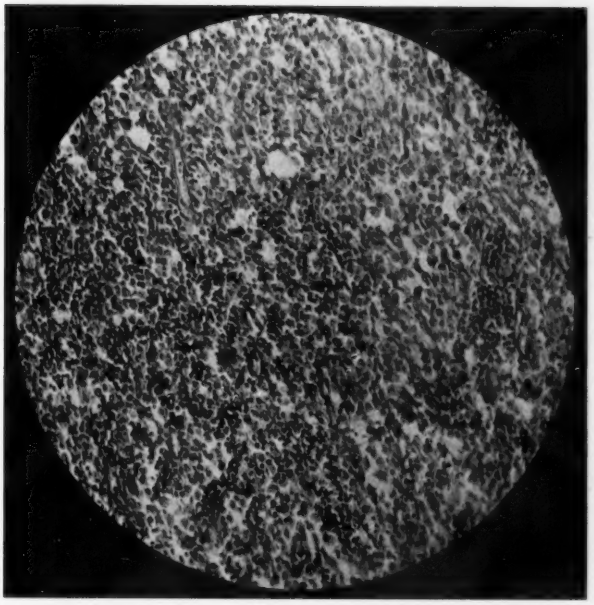


FIG 5.—Case 3, Neck table. One pathologist pronounced specimen round-celled sarcoma; another reported atypical Hodgkin's disease.

FIG. 6.—Pathological diagnosis was sarcoma, but clinical course was that of Hodgkin's disease.

FIG. 7.—Round-celled sarcoma.

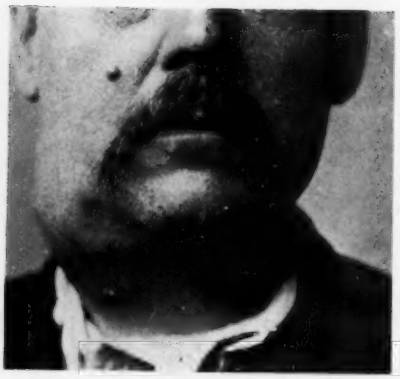


FIG. 8.—Case 12, Neck table. Round-celled sarcoma of neck. Decreased three-quarters in one week, but later increased. Patient died four months later.

FIG. 9.—Round-celled sarcoma of neck.

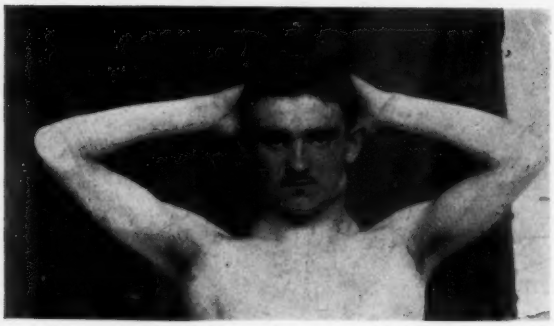


FIG. 10.—Hodgkin's disease.

FIG. 11.—Hodgkin's disease.

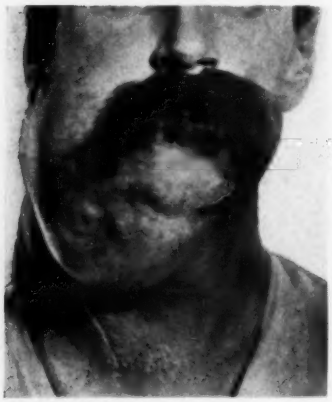


FIG. 12.—Lymphosarcoma of the neck. About thirty X-ray exposures before entering the hospital; no effect. Few treatments were given in hospital. Rapid progress.

FIG. 13.—Hodgkin's disease.

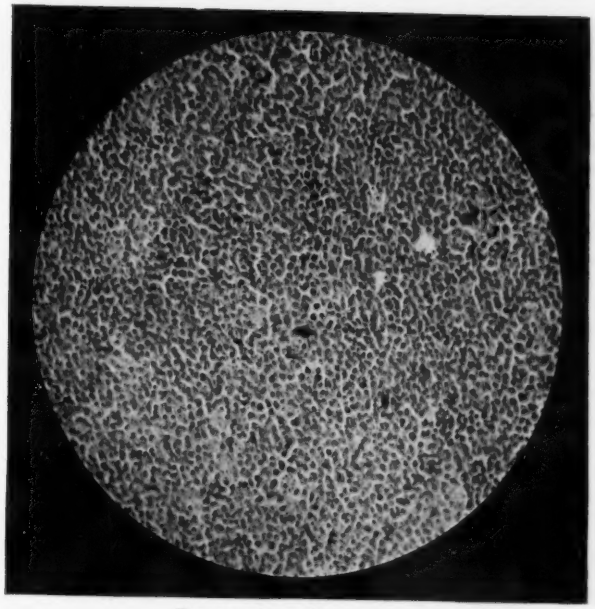


FIG. 14.—Lymphosarcoma.

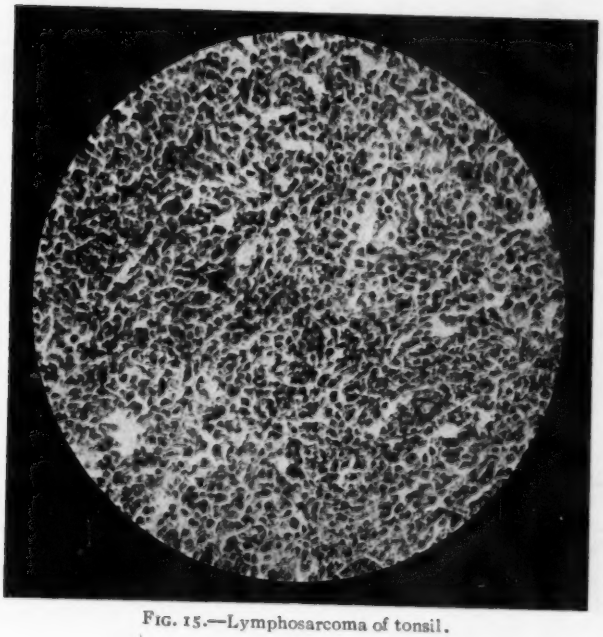


FIG. 15.—Lymphosarcoma of tonsil.

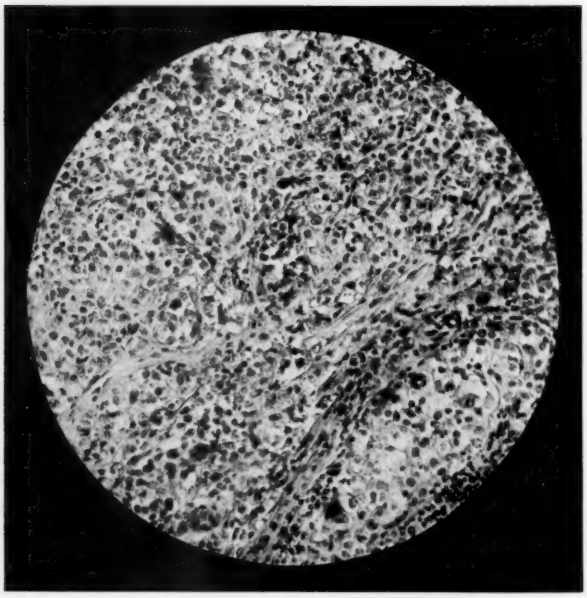


FIG. 16.—Lymphosarcoma of neck and tonsil.

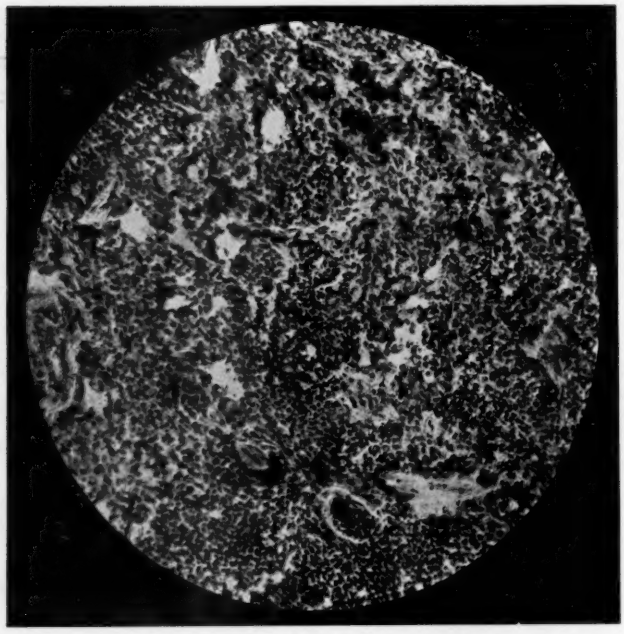


FIG. 17.—Inoperable recurrent sarcoma of neck. Entire disappearance under toxin treatment. Patient well at present, over six years later.

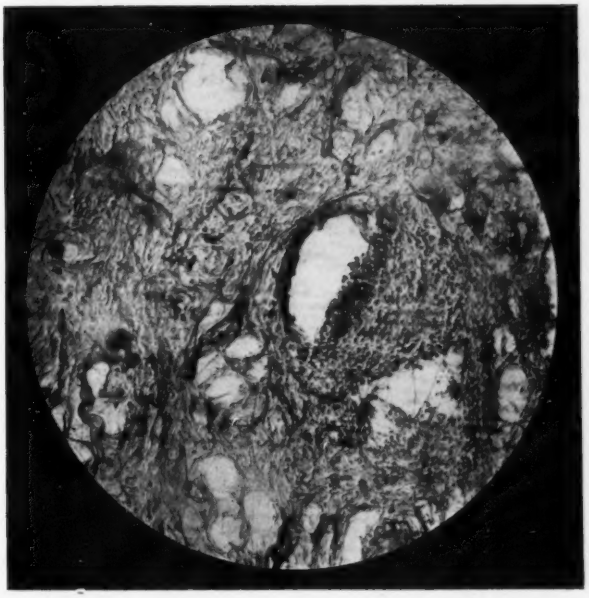


FIG. 18.—Recurrent sarcomatous (clinical diagnosis) glands of the neck; inoperable. Disappeared after use of toxins; well 2½ years, December, 1915.

FIG. 19.—Case 17. Mr. K., Neck table. Primary cervical glands. Papillary adenocarcinoma of neck (thyroid ?). Same as Fig. 20.

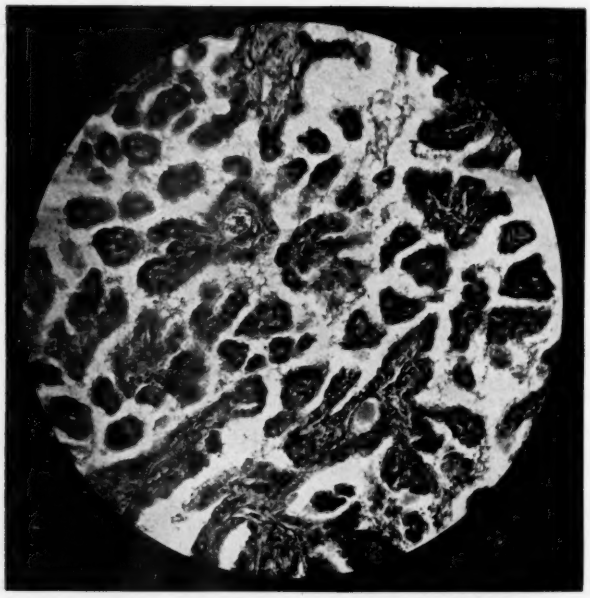


FIG. 20.—Mr. K. Angiopapillary endothelioma of neck.

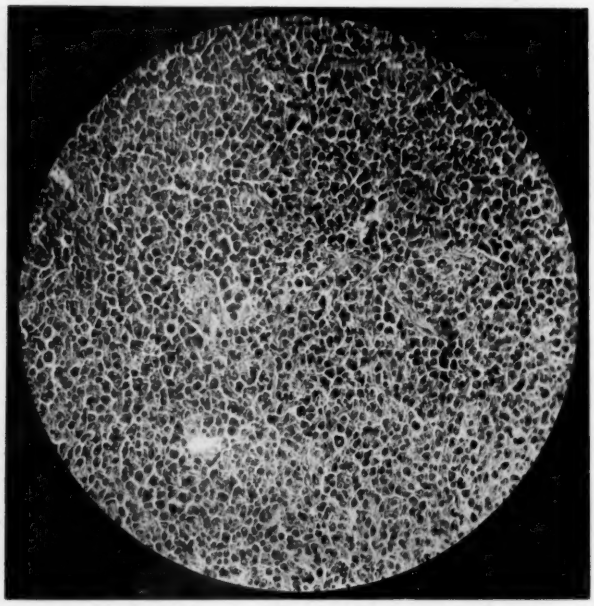


FIG. 21.—Lymphosarcoma of neck; recurrence after three operations; condition then inoperable. Entire disappearance and patient well at present 2½ years.

FIG. 22.—Sarcoma of neck.

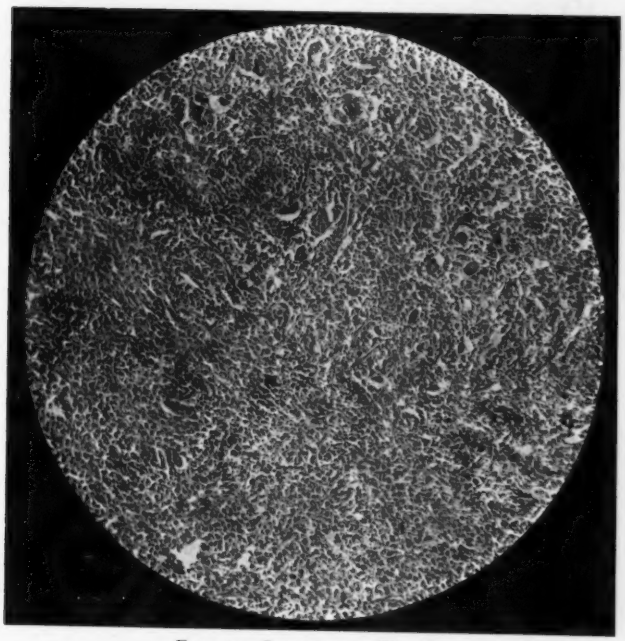


FIG. 23.—Same case as Fig. 22.

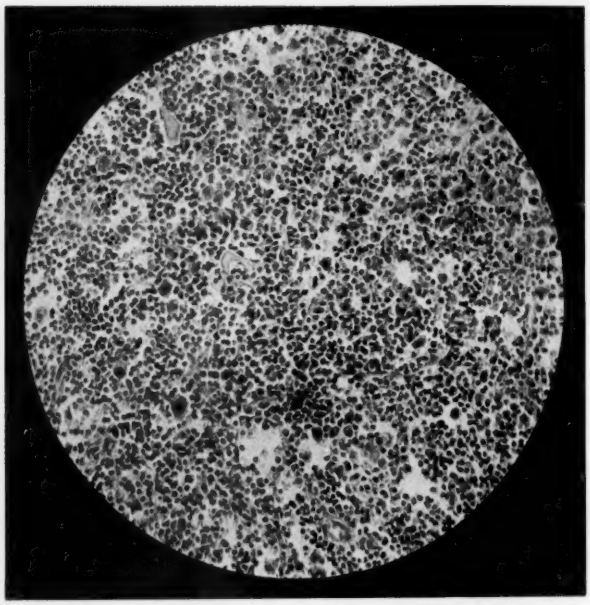


FIG. 24.—Lymphosarcoma of neck, or Hodgkin's disease.

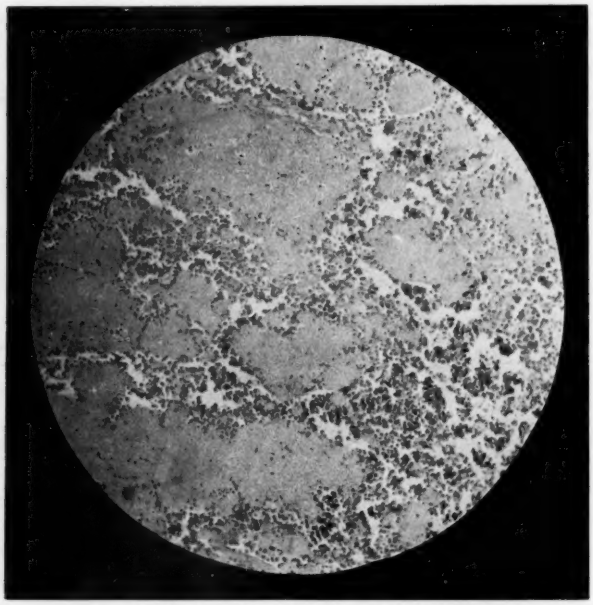


FIG. 25.—Lymphosarcoma of tonsil and neck (Dr. Ewing and also Bellevue Hospital Laboratory). Pure culture of diphtheroid bacillus obtained from gland in neck.

FIG. 26.—Axillary glands; rapid progress. One pathologist reported sarcoma; another melanoma.

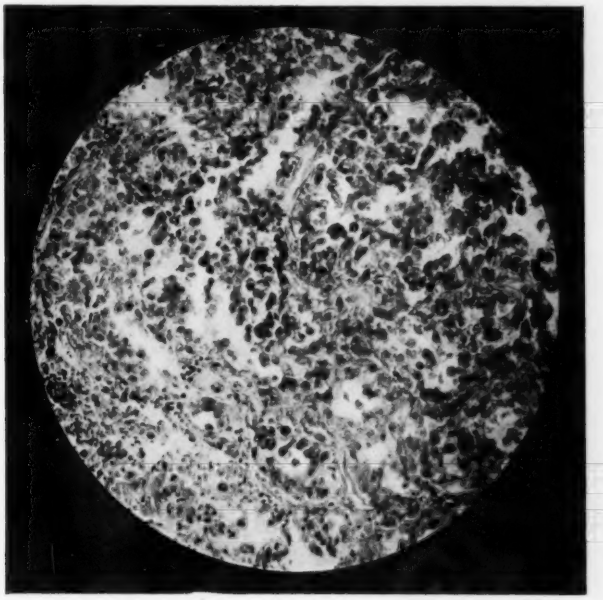
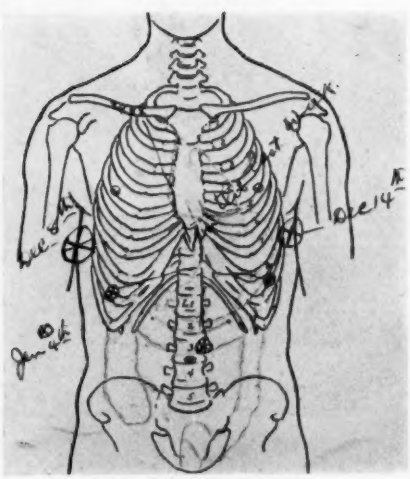
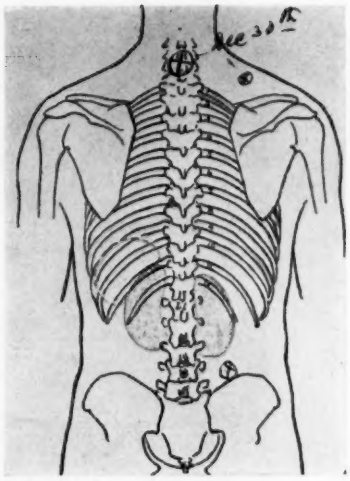


FIG. 27.—Melanoma; sarcoma of cervical glands; regarded as tuberculosis at first; two operations. Pathological report, melanoma. No primary pigment.





FIGS. 28 and 29.—Lymphosarcoma beginning in axillary glands. Death in 3 months.

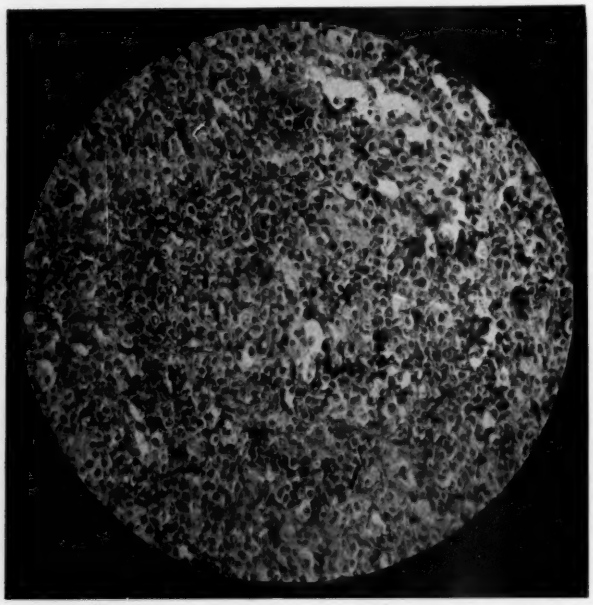


FIG. 30.—Lymphosarcoma of axillary glands or melanoma, (Ewing). Death in 3 months.

FIG. 31.—Benign tumor of the lymphatic glands, of twenty-one years duration. Lymphoadenoma (Ewing). Probable Hodgkin's (Roosevelt Hospital diagnosis).

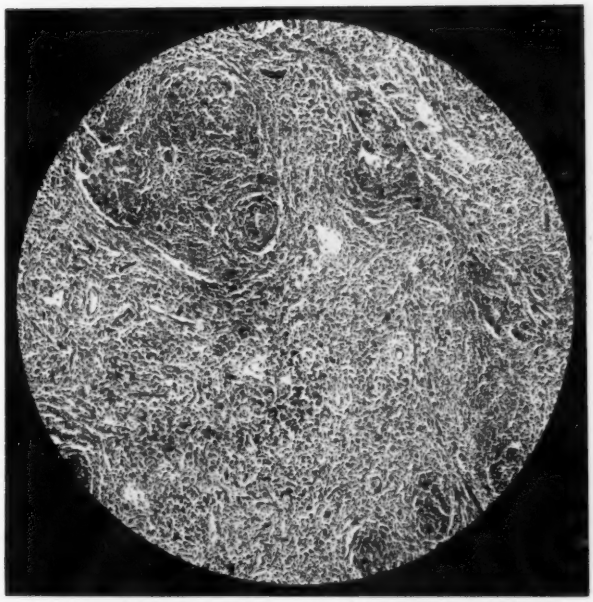


FIG. 32.—Neck case. Lympho-adenoma (Ewing). Hodgkin's (?), another diagnosis. Duration 21 years.

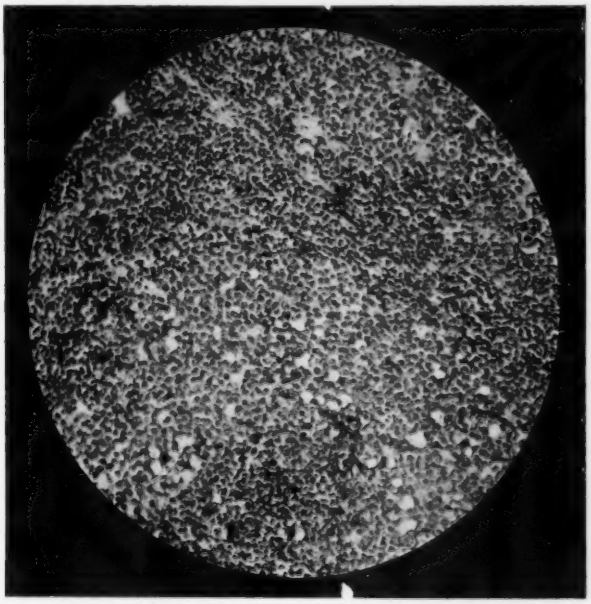


FIG. 33.—Case 15, Tonsil table. Before toxin treatment. Inoperable lymphosarcoma of tonsil and neck. Nearly disappeared after two months' toxin treatment, but then increased slightly. Removed by operation, and toxin treatment again given. Improved under radium and X-ray; later recurred. Still under treatment.

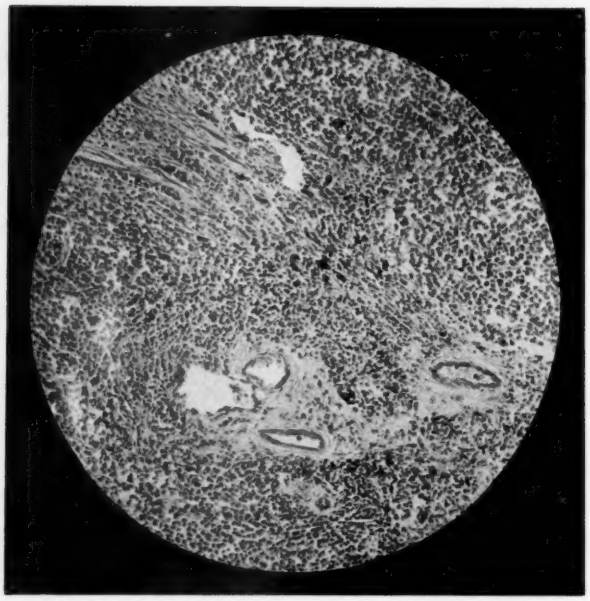


FIG. 34.—Case 13, Tonsil table. After toxin treatment. Lymphosarcoma of tonsil and neck; after toxins. There was increase in fibrous tissue after 12 months' toxin treatment.

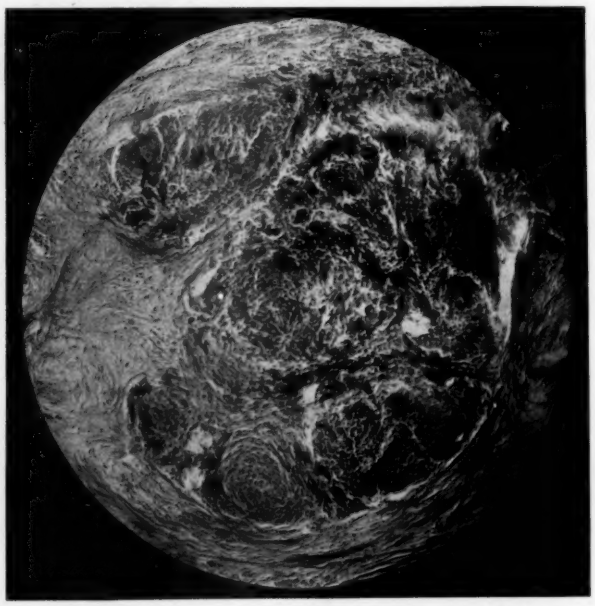


FIG. 35.—Case 13, Neck table. Tumor of carotid body.

put upon the toxins and while the disease was apparently held in check, there was no noticeable decrease in the size of the tumor. Under the combined toxin and radium treatment, which has been continued up to the present time, the tumor rapidly decreased in size and there is now scarcely more than an indurated edge at the site of the tumor. September 21, 1915: Local recurrence with cervical and mediastinal metastases has developed and general condition is rapidly growing worse in spite of continued toxin, X-ray, and radium treatment.

In connection with these recurrences, a brief reference to my first case treated with the living cultures of streptococcus of erysipelas in 1891, may be of interest: Inoperable spindle-celled sarcoma of the tonsil with extensive metastases on the neck; both primary and secondary tumors almost completely disappeared following an attack of erysipelas produced by inoculation in October, 1891. The patient remained well for eight years and then had a local recurrence which proved fatal within a year.

The most important lesson to be learned from a study of these recurrent cases I believe is that in many of them the treatment was not kept up sufficiently long.

I am convinced that it is better to continue the treatment longer than may be absolutely necessary in a certain number of cases, rather than run the risk of a recurrence by too short a course of treatment in certain other cases. In cases in which the toxins fail to control the disease I believe it advisable to use X-rays or radium or both in conjunction with the toxins.

A summary of the cases, 36 in number, successfully treated with the mixed toxins by other men, shows the following:

6 cases of sarcoma of the mesentery.

6 cases of sarcoma of the retroperitoneal glands.

17 cases of sarcoma of the neck.

3 cases of sarcoma of the tonsil and neck.

2 cases of sarcoma of the inguinal glands.

1 case of Hodgkin's disease (well seven years).

1 case of multiple sarcoma.

Of these 30 remained well from one to seventeen years.

21 remained well from three to seventeen years.

11 remained well from five to seventeen years.

7 remained well from twelve to seventeen years.

Most of these cases appear in tabulated form in my paper read before the Third International Conference of Cancer Research, Brussels, August 1 to 5, 1913.

TABLE OF 167 CASES OF PRIMARY NEOPLASM OF THE LYMPHATIC GLANDS INCLUDING HODGKIN'S DISEASE

NECK CASES

Name	Age	Sex	Date	Locality	Antecedent trauma or infection	Duration	Diagnosis, clinical	Diagnosis, microscopical	Treatment	Result, immediate	Result, final
1 H. W....	55	M	May, 1913	Neck	No	Few weeks	Sarcoma	Round-celled sarcoma	Operation; rapid recurrence; toxins 3 months; second incomplete operation; toxins one year	Entire disappearance	Well at present, two and a half years.
2 Dr. P. V..	40	M	1913	Neck	.....	A few months	Sarcoma	Infective granuloma; round-celled sarcoma	Operation; recurrence; toxins; disappearance. Recurred under small doses; again disappeared under large doses	Improvement, reduction of dose, rapid growth	Complete disappearance; well at present, 2½ years.
3 J. J. D...	55	M	1913	Neck	.....	16 months	Sarcoma	One pathologist, lymphosarcoma; Hodgkin's disease, another pathologist	Two operations; X-ray; toxins; temporary improvement; third operation, toxins	Temporary improvement	Death in 1914; duration of life one year.
4 P. K.....	41	M	1909	Neck	.....	2 months	Sarcoma	Small round-celled sarcoma. Dr. Hodenpyl, Roosevelt Hospital	Incomplete operation by Dr. Chas. Peck. Hopeless prognosis given	Entire disappearance under three months treatment; mixed toxins	Well at present; 6 years.
5 M. L. A..	40	F	1900	Neck supraclavicular	.....	4 years, then grew rapidly after injury	Sarcoma	Round-celled (small)	Recurred almost immediately and grew much more rapidly; soon extended into axilla; second operation (axilla)	Toxins begun Oct., 1900; marked improvement after 6 months; grew worse. X-ray used with great improvement	Improvement only temporary; died January, 1904; multiple metastasis.
6 J. M.....	27	M	1912	Neck	.....	2 years	Supposed to be tuberculosis at first	Spindle-celled sarcoma	First operation, 1908; second operation, 1911; March, 1912, inoperable recurrent tumors of neck and supraclavicular glands	Toxins given with intervals of rest; 2½ years; marked improvement, able to work all of the time	Became rapidly worse; Nov., 1914, operation; curetting; died Dec., 1914 (extension into mediastinum and probably lungs).
7 R. S.....	21	F	1896	Neck	.....	2 months	Sarcoma	Spindle-celled	Very rapid involvement whole neck and side of face, in two months; daily temperature 102°	Toxins tried 6 weeks; slight decrease at first	Later, no effect; duration of life, from first symptoms, 5 months.

8	L. M....	24	M	1914	Neck	.....	Felt unwell, 8 months; noticed tumor 6 months	Sarcoma	Round-celled sarcoma (large cells)	First operation, April, 1914; recurred 6 weeks; tumor size of small egg; July 10, 1914, toxins begun	Tumor nearly disappeared in 3 weeks; later increased some	Removed by operation; grew very much more rapidly after operation; toxins used; little effect.
9	J. H. R..	38	F	1909	Neck	No	7 months	Sarcoma	Lymphosarcoma	First operation, June, 1909; second operation, Sept., 1909; recurred; inoperable, Nov., 1909	Huge infiltrating tumor, Nov., 1909	Died few months later.
10	J. R....	13½	M	1909	Neck	No	6 weeks	Sarcoma	Lymphosarcoma	First operation, Feb. 24, 1909; recurred, inoperable, April, 1909	.....	Died few months later.
11	A. P....	2¼	F	1902	Neck	No	10 days	Sarcoma	Small round-celled. Dr. Steiner, pathologist, Hartford Hospital	First operation, January 27, 1902; second operation, few weeks later, March 8, 1902; whole neck involved, clavicle, and mastoid	Mixed toxins several months; no other treatment; entire disappearance	Well June, 1915; 13 years.
12	A. W...	49	M	1894	Neck	Repeated attacks quinsy	6 months	Sarcoma	Small round-celled	Tumor size of large orange, no operation; tumor reduced to size of small egg	After 1 week's toxin treatment again began to increase, no further control	Died in 2 months.
13	E. E....	35	M	1904	Neck and tonsil	No	4 months	Sarcoma	"Tumor of carotid gland"	Tumor, size of egg, pushing tonsil into pharynx	Removed by operation, incomplete operation	Not traced, probable death.
14	C. H....	35	M	1912	Neck	No	5-6 years	Sarcoma	Round-celled sarcoma	First operation, July, 1910, very extensive; ligature common carotid; inoperable, very extensive tumor	Oct., 1912, toxins 6 months; marked improvement; later X-ray and toxins; nearly complete disappearance of tumor	Died 1914, acute nephritis.
15	P. R....	44	F	1910	Neck	No	8 months	Sarcoma	Lymphosarcoma	First operation, Feb. 26, 1910; recurred in 9 weeks; June, 1910, tumor size of cocoanut	Toxins tried 3 weeks, no effect	Death few months later.

NECK CASES—*Continued*

	Name	Age	Sex	Date	Locality	Antecedent trauma or infection	Duration	Diagnosis, clinical	Diagnosis, microscopical	Treatment	Result, immediate	Result, final
16	M.W.B.	20	F	1910	Neck	No	1 year	Sarcoma	Exploratory operation; specimen pronounced negative	Very large tumor involving whole side of neck and extending into mediastinum	Toxins, 6 months; radium and X-ray continued; slow increase in size	1 year ago (1914) began to decrease in size; now ⅓ size of 2 years ago.
17	K.....	43	M	1911	Neck	.....	15 months	.....	Round-celled angiosarcoma, one pathologist, primary tumor; adenocarcinoma; recurrent tumor, Dr. Ewing	Incomplete operation, toxins	Almost complete disappearance; well 3 years; recurrence; operation and toxins and X-ray	Well nearly 1 year, Nov., 1915. Recurrence in mediastinum.
18	M.....	42	M	1898	Neck	.....	1¾ years	Sarcoma	Round-celled	Inoperable	Toxins, but little effect	Died in a few months.
19	M.....	30	M	1903	Neck	.....	10 months before operation	Sarcoma	Round-celled sarcoma (first operation, diagnosis tubercular)	First operation, Nov., 1902; second operation, Feb., 1903; third operation, July, 1903; recurred and grew very rapidly	Oct. 1, 1903, enormous infiltrating tumor; X-ray tried	No effect; prognosis hopeless.
20	T. M..	21	M	1907	Neck	.....	4 years before operation	Sarcoma	Small round-celled	First operation, 1902; small lump appeared in a few months; remained some 4 years, then grew rapidly	Toxins, 22 doses; unimproved	Died later.
21	H.....	38	M	1914	Neck and abdomen	.....	3 weeks	Sarcoma	Round-celled sarcoma (Dr. Ewing)	Enlarged glands in supraclavicular region, also large mass in abdomen; probably retroperitoneal	No operation; toxins 3 weeks; considerable decrease in size	Later no effect; Death in 2 months; whole duration of disease, 4 months.
22	L. S...	28	M	1912	Neck	.....	3 months	Sarcoma	First microscopical examination, hyperplasia; second, hyperplasia	First operation, Jan., 1912; second operation, April, 1912; tumors quickly recurred	Sept. 18, 1912, large inoperable tumor; clinical appearance typical of sarcoma	Died within 1 year.
23	L. S...	adult	F	1911	Neck	.....	Few months	Sarcoma	Polymorphous sarcoma (lymphosarcoma)	First operation, May 13, 1911; tumor size of fist removed; incomplete operation	.....	Death within few months.

24	Mrs. B.	60	F	1905	Neck	After strain of neck	1 year	Sarcoma	Fibrosarcoma	Incomplete operation, Feb., 1905; toxins	.....	Death.
25	G.....	25	M	1910	Neck	Followed grippe cold	3 months	Sarcoma (thought to be tubercular at first)	Sarcoma (Mayo Clinic)	Inoperable tumors, cervical and axillary region; toxins begun Oct., 1910	Axillary tumors reduced one-half in size; some loss of flesh	Improvement temporary; died within 1 year.
26	B.....	55	M	1913	Neck	Frequent attacks of quinsy	9 months	Sarcoma	Sarcoma or carcinoma (Ewing), section too thick	Inoperable tumor, size of fist; whole left cervical region	Toxins, 3 weeks; decrease in size; increased mobility	Soon grew worse and died Dec. 20, 1913.
27	A.....	41	M	1907	Neck	No	1 month	Sarcoma	Round-celled	First operation, Aug., 1905; recurred in 6 months; second operation, March, 1906; recurred Jan., 1909	.....	Died.
28	C.....	41	M	1911	Neck	No	4 months	Sarcoma	Round-celled	Exploratory operation, Sept. 15, 1911	Inoperable; toxins few weeks; temporary improvement	Not traced.
29	B.....	22	M	1908	Neck	Bad teeth	4 months	Sarcoma	Sarcoma	Recurred 3 weeks; operation Dec., 1907	Feb., 1908, inoperable	Died Sept. 8, 1908.
30	C.....	49	F	1899	Neck	No	5 years	Tubercular glands at first	Sarcoma	First operation, 1894, by Dr. Morris; second operation in 4 months; third operation in 2 years	January, 1899, inoperable, very large	Died within year.
31	M.....	56	M	1913	Neck	No	1 year	Sarcoma	Sarcoma, lymphosarcoma (Mayo Clinic)	Several operations, 1912–1913; inoperable, June, 1915	Recurrence, inoperable; toxins tried 6 weeks; little effect	Death in 6 months.
32	M.....	44	M	1896	Neck	No	1 year	Sarcoma	Round-celled	First operation, 1894; Dr. Mixter (called tuberculosis); second operation 6 months later; third operation 6 months later	Called tuberculosis up to fourth operation, then round-celled sarcoma	Toxins, temporary improvement; died.
33	P.....	20	M	1900	Neck	No	Few weeks	Sarcoma	Sarcoma	First operation Sept., 1899; small single tumor removed under angle of jaw; recurred in 3 weeks; grew rapidly	April, 1910, large inoperable, recurrent tumor; size of cocoanut; toxins, few weeks	Little improvement, died later, within 6 months.
34	N.....	40	M	1911	Neck	No	2 years	Sarcoma	Lymphosarcoma	Small nodule, quiescent 2 years, then sudden, rapid enlargement; operation, Feb. 11, 1911	Recurred in 3 weeks; April 13, 1911; large inoperable, whole right side neck; toxins	Very little improvement, died later.

NECK CASES—*Continued*

Name	Age	Sex	Date	Locality	Antecedent trauma or infection	Duration	Diagnosis, clinical	Diagnosis, microscopical	Treatment	Result, immediate	Result, final
35 C.....	4	F	1906	Neck	No	7 months	Supposed to be fatty tumor at first; back of neck	Small, round-celled sarcoma	First operation, March, 1906; second operation, August, 1906; 19 injections of toxins after second operation; third operation, Nov., 1906; toxins	Recurrence after each operation	Died, fall, 1907; probably cerebral sarcoma.
36 C.....	38	M	1902	Neck	No	6 months	Supposed to be tubercular at first; operation	Lymphosarcoma	First operation, Sept., 1901; curetting softened gland; rapid recurrence; second operation very extensive, Feb., 1902	Sept., 1902, very large inoperable tumor entire, supraclavicular and cervical regions	Forty X-ray, no effect; then took toxins; no effect; died shortly after.
37 C.....	37	M	1908	Neck	No	Symptoms 6 months; tumor 2 months	Tumor	Lymphosarcoma (Dr. Whitney, Harvard)	Inoperable tumor, supraclavicular, June 8, 1908; toxins	Little effect	Death within 1 year.
38 C.....	51	M	1908	Neck	No	3 months	Tuberculosis after first operation	Spindle-celled sarcoma	First operation, July, 1908; X-ray used three times a week, very powerful tubes; no effect on rapid growth of tumor, Sept., 1908; tumor size of fist, inoperable; loss of weight	Toxins brief period, little effect	Died Sept., 1908.
39 K.....	49	M	1899	Neck	Blow on neck from board, 4 months before	Tumor stationary 2 years, then grew; both sides neck	Sarcoma	Lymphosarcoma	Inoperable when first seen; electric treatment 6 months, no effect	.....	Died.
40 C.....	44	M	1912	Neck	Stiff neck year before	5 months	Lymphosarcoma	Malignant tumor—exact natu e could not be determined	Local treatment, later toxins	Temporary improvement	Died in a few months.
41 L.....	28	M	1899	Neck	No	2 months	Began right submaxillary gland; both sides, later	Lymphosarcoma	Toxins	Toxins, one week; little effect	Died within 1 year.

42 H.....	49	F	1906	Neck	No	2 years	Began in single gland, then several fused in large tumor	Lymphosarcoma	No operation; inoperable; X-ray prolonged treatment, no effect; toxins given 1 month, no effect	No effect	No effect; died within 1 year.
43 D.....	60	M	1898	Neck	No	4 months, back of neck	Sarcoma	Lymphosarcoma	Inoperable when first seen	Toxins, 4	Little effect; death.
44 O.....	27	M colored	1900	Neck	No	1 year	Sarcoma	Lymphosarcoma	Tumor size of 2 fists, freely movable; operation (Dr. Coley), May 12, 1900	No other treatment; well 4 months later	Not traced.
45 Y.....	22	M	1899	Neck	No	18 months	Sarcoma	Lymphosarcoma	Aug. 4, 1899; tumor one-half size cocoanut; inoperable	.....	Died.
46 L.....	19	M	1909	Neck	No	1 year	Sarcoma	Lymphosarcoma	First operation, Dr. Vander Veer, Dec. 1, 1908; second operation, March, 1909; May 26, 1909, inoperable; recurrence	.....	Died.
47 M.....	21	M	1907	Neck	No	3 months (both sides neck)	Sarcoma	Round-celled sarcoma	First operation, June, 1906; June, 1907, inoperable recurrence; treated at General Memorial Hospital, 1907; toxins + X-rays	Marked decrease in size at first	Later no effect.
48 B.....	56	F	1910	Neck (supraclavicular)	Yes, struck by windlass	Pain 2 months before swelling	Sarcoma	Round-celled sarcoma	Operation, Feb., 1910; Dr. DaCosta; toxins begun July, 1910; kept up 2 months	Little effect	Died Oct. 1, 1910.
49 S.....	15	F	1899	Neck	No	2 months	Sarcoma	Lymphosarcoma	Operation Oct., 1899; Mt. Sinai Hospital; tumor size orange	Local recurrence, inoperable, Dec., 1899	?
50 S.....	58	M	1910	Neck	Followed severe cold	6 months	Sarcoma	Lymphosarcoma	Jan. 19, 1910; inoperable, whole left side, neck, mastoid and clavicle	.....	Died within 1 year.
51 W.....	46	F	1909	Neck (supraclavicular)	Blow from a falling window	Tumor 1 week after blow	Sarcoma	Lymphosarcoma	Toxins begun spring, 1909; 78 injections prior to July 12, 1909	Marked decrease in size	Died about 1 year later.

NECK CASES—*Continued*

Name	Age	Sex	Date	Locality	Antecedent trauma or infection	Duration	Diagnosis, clinical	Diagnosis, microscopical	Treatment	Result, immediate	Result, final
52 W.....	37	F	1905	Neck	No	1 month	Sarcoma	Round-celled	Operation, Dr. Woolsey, Aug. 9, 1905; wound never healed; rapid recurrence	Recurrence, Dec., 1905; whole side of neck involved, very large infiltrating tumor; toxins, little effect	Died shortly after.
53 V.....	46	M	1908	Neck	No	9 months	Sarcoma	Round-celled	Operation, Dr. Blake; January, 1908; recurred in 2 weeks	Inoperable	Death within few months.
54 V. P....	37	M	1902	Neck	No	6 months	Sarcoma	Round-celled	Operation, Nov., 1902	Inoperable recurrence and toxins; X-ray, Dec. 25, 1902; little effect	Death within few months.
55 S.....	31	F	1911	Neck	No	1½ years	Sarcoma	Round-celled	Operation Oct., 1910; inoperable	Recurrence, April 12, 1911; toxins; little effect	Death.
56 S.....	29	M	1912	Neck	No	6 weeks	Sarcoma	Mixed-celled	Operation, Dr. Howe, Hartford, April 8, 1912; incomplete removal, rapid growth; July 3, 1912, inoperable; toxins	Temporary improvement	Died within a year.
57 S.....	28	M	1900	Neck	Strain muscles of neck	Pain at once, continued; tumor 4 months	Sarcoma, round-celled	Sarcoma	First operation, Sept. 6, 1899; recurred soon after	Recurrence; April 13, 1900, inoperable tumor, size 2 fists firmly fixed; toxins	Little effect; death in one year.
58 W.....	58	M	1908	Neck	No	2 years	Sarcoma	Round-celled	First operation, Nov. 1908; Dr. Gray, of Lynn, Mass.; incomplete operation	Dec. 21, 1908, inoperable recurrence; toxins begun and continued 3 months	Entire disappearance; patient well, June, 1915; 6½ years.
59 R.....	43	M	1907	Neck	No	6 months	Sarcoma	Spindle-celled	First operation, Jan., 1906; second operation, Jan., 1907; July, 1907, inoperable recurrence; ligature common carotid; toxins, 20 injections	Very little improvement	Died few months later.

60	L.....	26	F	1899	Neck	No	5 months	Sarcoma	Lymphosarcoma	First operation, May, 1899; second operation, Sept., 1899; recurred both sides; rapid growth	Oct., 1899, inoperable; hopeless condition	Death soon after.
61	G.....	47	M	1899	Neck, supraclavicular	No	9 weeks	Sarcoma	Lymphosarcoma	Inoperable tumor, supraclavicular; severe pain in arm, pressure on nerves; marked loss power right arm and leg; no operation	.....	Death.
62	G.....	41	M	1910	Neck	No	3 months	Sarcoma	Lymphosarcoma	First operation, June, 1910; second operation, July, 1910	Recurrence; toxins, marked improvement; later operation	Final result not known.
63	S.....	53	M	1914	Neck	.....	.....	Sarcoma	.....	.....	Metastases in brain	Death.
64	S.....	18	M	1914	Neck	No, tonsillitis	Pain 2 years, lump in neck 1½ years	Sarcoma	Sarcoma	Operation, Jan., 1914	Recurrence; toxins, April, 1914, 1 month	Unimproved.
65	W.....	19	M	1913	Neck and mediastinum	No	.....	Sarcoma	.....	Toxins + X-ray	Temporary improvement	Death within 4 months.
66	D.....	19	F	1915	Neck	No	2 months	Sarcoma	Tumor, thymus gland	Two operations	No improvement	Died in 3 months.
67	J.....	31	M	June 1908	Neck	Sprain from lifting heavy weight	4 days	Hodgkin's	Sarcoma; Prof. Potter, Cornell University, Ithaca	First operation, Feb. 7, 1905; rapid recurrence; second operation, May, 1905; local recurrence and axillary glands; X-ray after second operation; liver enlarged, but not spleen	Temporary improvement	Died Sept. 1, 1908.
68	J.....	9	M	1912	Neck	Followed attack of the measles in 1910	.....	Hodgkin's	1912, sarcoma, Coll. P. and S. 1914, Dr. Ewing, simple lymphoma	Gland removed for microscopical examination, 1912; toxins begun Oct., 1912; severe reactions	Glands all disappeared; recurred in spring, 1914; toxins again started	Almost entire disappearance under 4 months' toxin treatment; well Dec. 1, 1915.
69	M.....	43	F	1914	Submaxillary region; neck	.....	2½ years	Sarcoma	Chronic adenitis, first operation; tuberculosis, second operation; third operation, melanotic sarcoma; fourth operation, melanoma, malignant; fifth operation, melanoma	Four operations; recurrence, toxins; decrease in size, rendering fifth operation, partial, feasible; followed by toxin treatment	Recurrent after 4 operations, toxins; decrease in size, partial operation followed by toxins	So far free from recurrence; still under treatment, Nov., 1915.

NECK CASES—*Continued*

Name	Age	Sex	Date	Locality	Antecedent trauma or infection	Duration	Diagnosis, clinical	Diagnosis, microscopical	Treatment	Result, immediate	Result, final
70 B.....	Adult	M	1911	Neck and tonsil	No	Few months	Sarcoma	Lymphosarcoma, Mt. Sinai Hospital	Glands removed, 1908; X-ray	Tumor disappeared, April, 1911; signs of metastasis in abdomen; Aug., 1911, enlarged spleen and liver and inguinal glands	Death in few months.
71 McN...	60	F	May, 1915	Neck	.....	6 months	Sarcoma	Spindle-celled sarcoma	Operation, recurrence, toxins	Disappearance under 3 weeks' toxin treatment	Still under treatment, no evidence of a return Dec. 15, 1915.
72 J.....	..	F	1913	Neck	.....	3 months	Sarcoma	Simple lymphoma; chronic lymphadenitis; sarcoma	Two operations, recurrence; radium	Slight temporary improvement	Death one year after onset.
73 L.....	31	M	Nov. 1908	Neck	Scantling fell 6 feet, striking neck, subject to tonsillitis	2 years	Sarcoma	Lymphosarcoma by one pathologist; endothelioma by another; later, lymphoma	Operation; toxins	Remained well for 6 months, then recurrence; toxins and various vaccines tried without avail	Died Nov. 5, 1910.
74 H.....	70	M	May, 1901	Neck	.....	10 years	Sarcoma	General round-celled sarcoma	Five operations held growth in check for 10 years, then X-rays	Final disappearance	Two years later, recurrence which caused death.
75 G.....	56	M	June, 1915	Neck	.....	21 years	Sarcoma	Lympho-adenoma, Dr. Ewing; granuloma, probably Hodgkin's, Roosevelt Hospital	Operation 15 years ago; recurrence, X-ray treatment; vaccine treatment	No improvement	Still under X-ray treatment.
76 M.....	53	F	March, 1896	Submaxillary region; also carcinoma of breast	.....	4 months	Typical sarcoma	Glandular hyperplasia; later, round-celled sarcoma	Inoperable, became operable under toxin treatment	Recurrence 4 months later, operation again followed by recurrence; very rapid growth	Died March 18, 1897, from exhaustion.

SARCOMA OF TONSIL AND NECK

	Name	Age	Sex	Date	Locality	Antecedent trauma or infection	Duration	Diagnosis, clinical	Diagnosis, microscopical	Treatment	Result, immediate	Result, final
1	W.....	56	M	May, 1910	Tonsil and neck	No trauma; smoker	Noticed 2 months; tonsil and cervical glands	Sarcoma	Round-celled sarcoma	Inoperable; portion removed for microscopical examination	Entire disappearance of tumors	Patient alive, no recurrence 5½ years later.
2	S.....	55	M	Nov., 1909	Tonsil and neck	Followed tonsillitis, temperature 102°–103°	2 weeks	Sarcoma	Lymphosarcoma	Inoperable; gland removed for microscopical examination; one dose toxins, ¼ minim	Condition did not warrant continuing	Death 2 days later.
3	Z.....	29	M	April, 1914	Tonsil and neck	Followed tonsillitis 5 months ago	5 months	Sarcoma	Lymphosarcoma from specimen of neck; autopsy diagnosis lymphatic leukæmia	Toxins, autogenous vaccines and X-ray	No improvement	Death, June 28, 1914; autopsy, Dr. Ewing.
4	M.....	25	M	July, 1911	Tonsil and neck	No history of tonsillitis	5 months	Sarcoma	Sarcoma	Inoperable	.....	Death.
5	F.....	42	M	May, 1914	Tonsil and neck	No history of tonsillitis, negative Wassermann	1 year	Sarcoma	Round-celled sarcoma, tonsil and neck (Dr. Ewing)	Inoperable, mixed toxins, 4 weeks	Very marked decrease in size; recurred 2 – 3 weeks later; toxins lost control	Death July, 1914.
6	M.....	43	F	May, 1913	Tonsil and neck	Subject to tonsillitis	3 months	Sarcoma	Lymphosarcoma			
7	D.....	53	F	1896	Tonsil and neck	No	Few weeks	Sarcoma	.....	Inoperable, 7 injections of toxins	No effect	Not traced.
8	D.....	52	M	1909	Tonsil and neck	No	2 years	Sarcoma	Sarcoma	Operation tonsil, 1908; recurred in neck 3 months; inoperable	.....	Died.
9	A. L....	10	F	1906	Tonsil and neck	No	Small swelling 1 year before subsided; rapid growth 2 months	Large inoperable tumor, right tonsil, nearly blocking up pharynx	Small round-celled sarcoma	Toxins begun and kept up for six months	Entire disappearance	Patient well, Nov., 1915; nine years.

SARCOMA OF TONSIL AND NECK—*Continued*

Name	Age	Sex	Date	Locality	Antecedent trauma or infection	Duration	Diagnosis, clinical	Diagnosis, microscopical	Treatment	Result, immediate	Result, final
10 McA...	24	M	1912	Tonsil and neck	Following severe cold	Few months	Sarcoma	Lymphosarcoma	Toxins, 3 months; temporary improvement, vaccines and diphtheroid bacillus cultures; temporary improvement; X-ray, temporary improvement	Temporary improvement	Later very rapid growth; death, general metastases, 8 months from beginning of treatment.
11 O.....	24	M	1913	Tonsil and neck	No	10 months	Sarcoma	Large round-celled sarcoma	Section removed for diagnosis; toxins, June 29, 1913	Marked decrease in size	Temporary only.
12 M.....	32	M	1905	Tonsil and neck	No	1 month before operation	Sarcoma	Round-celled sarcoma	Incomplete operation, tonsil and neck, Aug., 1905; rapid recurrence, inoperable tumor, neck and tonsil, size of orange, Oct., 1905; toxin treatment	Entire disappearance in 8 weeks; recurred other tonsil 6 years later	Died 4 months after recurrence.
13 C.....	43	M	1915	Tonsil and neck	No	6 months before first operation	Sarcoma	Lymphosarcoma	Operation, local recurrence soon after; inoperable Feb. 19, 1915; toxins	Tumor reduced to ¼ original size in 6 weeks; improvement, then ceased; remainder removed by operation	Recurrence; tumor rapidly decreasing in size under toxin and radium treatment; still under treatment.
14 L.....	47	M	May, 1913	Tonsil and neck	No	.....	Sarcoma	Lymphosarcoma	Operation by Dr. J. L. Erdmann; recurred, inoperable; toxins 2 months	Temporary improvement	Died 6 months later.
15 C.....	42	M	1906	Tonsil and neck	Followed severe cold	5 months; marked loss of weight	Sarcoma	Round-celled; inoperable	Toxins, May 29, 1906; large doses	Entire disappearance 6 months; recurred 1½ years later; rapid growth	Death 6 months after recurrence.
16 P.....	66	M	1905	Tonsil, no glands	No	1 month before operation	Sarcoma	Sarcoma, Dr. Leland, of Boston	First operation, Oct., 1905; immediate local recurrence; second incomplete operation; toxins	Not traced	Not traced.
17 S.....	63	M	1908	Tonsil and neck	Followed attack of tonsilitis 1 week before	1 week, very rapid growth; inoperable in 2 weeks	Sarcoma	.....	Sept. 22, 1908; very large inoperable tumor of tonsil and whole right cervical region; toxins short time	Little effect	Died few months later.

18	C.....	51	M	1900	Tonsil and neck	No	11 year	Sarcoma	Sarcoma	First operation 11 years before; local return soon, slow growth; second operation 5 years later; recurrence in 3 years; third operation, Aug., 1898; March, 1900, inoperable; local recurrence	Recurrent after 3 operations	Died.
19	H.....	Adult	M	1914	Tonsil and neck	No	5 months	Sarcoma	Lymphosarcoma, glands, neck; round-celled sarcoma, tumor of tonsil	First operation Feb. 28, 1913, Mayo's Clinic; glands of neck removed; second operation 2 months later, Mayo Clinic; encapsulated tumors of tonsil removed, May, 1914; block dissection of neck, followed by toxins; slight recurrence noted; toxins continued at home	Recurrence after 3 operations	Died.
20	W.....	49	M	1898	Tonsil and neck	No	3 months	Sarcoma	Sarcoma	Incomplete operation; swelling of glands few days later; Dec., 1898, tumors of tonsil and neck; inoperable, later size of fist	Recurred	Death in few months.
21	C.....	48	F	1895	Tonsil and neck	No	Oct., 1894, noticed enlarged tonsil	Sarcoma	Round-celled sarcoma	First operation, Oct., 1894; second operation, April, 1895; recurrence, rapid increase in size; toxins 4 weeks	No improvement	Death few months later.
22	R.....	19	M	1913	Tonsil	No	.....	Sarcoma	Large round-celled lymphosarcoma	Inoperable; toxins, 48 injections	No improvement.	
23	F.....	19	M	1914	Tonsil and neck	No	2 months, right side; 1 month, left	Sarcoma	Lymphosarcoma	Radium and X-ray treatment and removal of tonsils		
24	Z.....	31	M	1891	Tonsil and neck	No	1 year	Sarcoma	Spindle-celled	3 operations, recurrence; inoperable	Inoculation of living cultures of erysipelas, 3 months, then severe attack of erysipelas by inoculation	Well 8 years, then died of local recurrence.

SARCOMA OF AXILLARY GLANDS

Name	Age	Sex	Date	Locality	Antecedent trauma or infection	Duration	Diagnosis, clinical	Diagnosis, microscopical	Treatment	Result, immediate	Result, final
1 F.....	35	M	1911	Axilla and neck	No	8 months	Sarcoma	Lymphosarcoma	Two operations; X-ray; toxins	Tumors disappeared under toxin treatment	No recurrence of disease; good general condition, June, 1915.
2 B.....	2	M	1902	Axilla	No	8 months	Sarcoma	Small round-celled sarcoma	Operation Jan., 1902	Recurred soon; inoperable, Feb. 6, 1902; toxins short time, little effect	No improvement.
3 W.....	36	F	1910	Axilla	Trauma, kicked by infant	Tumor, 3 months later	Sarcoma	Small round-celled	Operation May, 1910, rapid recurrence; toxin treatment; little effect	Rapid growth	Death July 10, 1910; duration of life from beginning of disease, 5 months.
4 G.....	50	M	1905	Axilla	No	Few months	Sarcoma	Sarcoma	First operation Jan., 1904; second operation, April, 1904; local recurrence, Jan., 1905; inoperable	.....	Death within year.
5 R.....	29	M	1911	Axilla	.....	.....	Sarcoma	Round-celled sarcoma; lymphosarcoma	Two operations; toxins after recurrence following second operation	Entire disappearance under 4 months' treatment with mixed toxins	Well four years.
6 W.....	27	F	1893	Axilla	Cut hand on vase	3 years	Sarcoma	Round-celled sarcoma	Incomplete operation; a few injections of toxins	No effect, tumor grew rapidly	Death 3 years from time of injury.
7 P.....	47	F	1911	Axilla	No	9 months	Sarcoma	Round-celled	First operation Jan., 1911; second operation June, 1911	Recurrence; inoperable, Sept., 1911	
8 G.....	40	F	1906	Axilla	No	Few months	Sarcoma	Lymphosarcoma	Operation March 23, 1906; adherent to axillary vein, incomplete removal; toxins for number of months	Complete recovery	Well without any return of disease Jan., 1915, 9 years later.

9 F.....	25	M	1913	Axilla	.....	Noticed only 6 weeks before operation	Lymphosarcoma	Lymphosarcoma	First operation Aug., 28, 1913; recurrence; second operation Sept. 22, 1913; recurrence; toxins begun Nov., 1913, continued large doses, partial operation Dec. 24, 1913	Grew worse rapidly	Died Feb., 1914.
10 W.....	69	M	1912	Axilla	2 years	Nearly disappeared spontaneously then, 1 year ago, began to grow again	Lymphosarcoma	Lymphosarcoma	Operation Feb., 1912	Recurred in 4 weeks, in pectoral and axillary region; inoperable	Death within year.
11 L.....	63	M	1895	Axilla	.....	Noticed tumor a few months	Sarcoma	Round-celled	Operation Bellevue Hospital, Feb. 11, 1895; local recurrence 6 months later; Inoperable Oct. 11, 1895; toxins 10 days; patient's condition too poor to continue	No effect from few treatments	Died a few months later.
12 B.....	67	M	Jan., 1911	Axilla	.....	3 years	Sarcoma	Lymphosarcoma, endothelioma	Incomplete removal of tumor in 1911 followed by toxins	Well 2 years, then recurred; operation; toxins again; disappearance	Well Jan., 1915, 4 years.
13 I.....	57	M	1914	Axilla and mediastinum	.....	1½ years	Sarcoma	Embryonal carcinoma	Glands removed for microscopical examination; in hospital one month	.....	Unimproved.
14 E.....	36	F	1914	Axilla	No exciting cause	3 months	Sarcoma	(1) Perivascular hemangio-sarcoma. (2) Mixed-celled sarcoma. (3) Melanoma, Dr. Ewing	First operation April 11, 1913, followed by Coley's toxins; July 4, recurred; July 23, second operation, Coley's toxins; second recurrence Nov. 29; Jan. 5, 1914, third operation, toxins and X-ray	Recurred in few weeks; fourth operation followed by recurrence	Died in Aug., 1914
15 D.....	33	F	1913	Axilla, scapula, chest-wall and clavicle	Following a blow	10 years	Sarcoma	Neurosarcoma	3 operations followed by recurrence; toxins; partial operation followed by toxins; again recurrence; operation; toxins	Entire disappearance of clavicle tumor under toxins	Examination Aug. 1, 1915; no return of tumor of chest wall, but clavicle shows some enlargement.

SARCOMA OF AXILLARY GLANDS—*Continued*

Name	Age	Sex	Date	Locality	Antecedent trauma or infection	Duration	Diagnosis, clinical	Diagnosis, microscopical	Treatment	Result, immediate	Result, final
16 W.....	24	M	Jan., 1915	Axillary glands	Attack of influenza	5 weeks	Sarcoma	Round-celled sarcoma or melanoma	A few doses of the toxins; no effect	Rapid progress of disease; general involvement of glands	Death within 5 weeks.
17 L.....	38	F	Oct., 1913	Axillary glands	.....	9 months	Sarcoma or Hodgkin's disease	Malignant adenocarcinoma of lymph-node	Operation	No recurrence	Well at present, July, 1915.
18 W.....	60	F	Sept., 1912	Axillary glands	.....	1 year	Carcinoma	Typical carcinoma	Operation, followed by toxins	Remained well one year, then local recurrence; second operation, toxins; again recurrence one year later; third operation; Jan., 1915, recurrence in clavicle; later also locally	Steadily growing worse, Dec., 1915.

SARCOMA OF MEDIASTINAL GLANDS

1 B.....	53	M	Nov., 1908	Mediastinal glands	.....	1¾ year	Malignant tumor, clinical and X-ray diagnosis	No microscopical examination	Toxin treatment 1½ years, followed by X-ray treatment 2 years later	Slow, but steady diminution in size of tumor and improvement	Patient in good health, October, 1914; 6 years.

INGUINAL GLAND CASES

Name	Age	Sex	Date	Locality	Antecedent trauma or infection	Duration	Diagnosis, clinical	Diagnosis, microscopical	Treatment	Result, immediate	Result, final
1 R.....	18	F	1894	Inguinal glands	No	2 months	Sarcoma	Round-celled	First operation, June, 1894; recurred in 2 months; toxins 2 weeks, no benefit; second operation	Recurrence	Oct., 1894, rapid growth; death in few months.
2 E.....	61	M	1904	Inguinal glands	6 months, no trauma; treated for hernia at first	.....	Sarcoma	Round-celled	First operation Nov., 1903; Feb. 8, 1904, inoperable recurrence	X-ray treatment, little effect	Died shortly after.
3 L.....	55	M	1906	Inguinal glands	Strain 2 weeks before tumor noticed	Grew very rapidly	Sarcoma	Round-celled	Operation January, 1906; recurred in few days, other groin and axilla	March, 1906, inoperable, marked emaciation; confined to bed	Death; whole duration of disease less than six months.
4 S.....	5½	M	1899	Inguinal glands	Injured groin from fall	Tumor, few days later; very rapid growth	Sarcoma	Small round-celled	Operation, Dr. W. F. Bull; incomplete removal; very rapid recurrence; toxins, 3 weeks	Improvement temporary	Died April, 1900; duration disease 11 months.
5 B.....	63	M	1909	Inguinal glands	No	Several months	Sarcoma	Round-celled	First operation March, 1909; recurred July, 1909; second operation, wound infected; phlebitis; recurrence in groin and abdomen; toxins begun Dec. 6, 1909; continued to Feb., 1910	Little effect on tumor	Died May, 1910.
6 C.....	39	M	1898	Inguinal glands	Yes, blow in groin	Tumor shortly after, stationary, 4 years, then grew	Sarcoma	Round-celled	Operation Sept., 1897; recurred locally in few weeks and later in both sides of neck	.....	Died in few months.
7 L. S....	47	F	1915	Inguinal glands	No	2 years	Sarcoma	Lymphosarcoma	2 operations, 1914; X-rays; toxins begun April 10, 1915	Glands have entirely disappeared	Recurred in few months, probably in spine. Condition hopeless, Dec. 15, 1915.

INGUINAL GLAND CASES—*Continued*

Name	Age	Sex	Date	Locality	Antecedent trauma or infection	Duration	Diagnosis, clinical	Diagnosis, microscopical	Treatment	Result, immediate	Result, final
8 D.....	30	M	1912	Inguinal glands	No	3 months	Sarcoma	Lymphosarcoma (Dr. Ewing); tuberculosis (Dr. Clark). Subsequent history proved it sarcoma	Exploratory operation, tumor size of goose egg removed for examination	Decreased to one-fourth original size under toxin treatment only, later began to increase; colloid copper tried, no effect	Emaciation and death in five months from beginning of disease.
9 G.....	45	F	1912	Inguinal glands	.....	Few weeks	Sarcoma	Round-celled	First operation, May, 1912; inoperable recurrence July, 1912; toxins, 4 months	Tumor disappeared	Jan., 1913, developed paralysis, arm and leg; no other evidence, metastasis; died Feb., 1913.
10 G.....	23	F	1909	Inguinal glands	No	1½ year, slow growth, normal labor Nov. 26, 1908	Sarcoma	Lymphosarcoma	First operation, Aug., 1908, Dr. Asa Davis; incomplete removal	Rapid recurrence	Died.
11 M.....	23	M	1909	Inguinal glands	No	6 months, œdema, leg, 2 months later	.....	Endothelioma	Exploratory operation only; Sept. 15, 1909; toxins	Little effect	Rapid progress.
12 P.....	7	M	1910	Inguinal glands	Yes, kick in groin	Tumor, a few days later	Sarcoma	.....	First operation Sept., 1910; tumor size of egg removed; recurrence in few weeks; toxins	Disappearance under toxins	Well 1915, 4½ years.
13 S.....	54	M	1898	Inguinal glands	No	8 months before first operation	Sarcoma	.....	First operation Sept., 22, 1896	1½ years later, local, inoperable recurrence; toxins	Little effect.
14 B.....	21	M	1908	Inguinal glands	Blow in groin	Tumor one week later	Sarcoma	Small round-celled sarcoma	First operation Feb., 1908; local recurrence in inguinal and iliac glands, March 26, 1908; toxins, partly by family physician	Tumors nearly disappeared; recurrence Oct. 19, 1908; disappearance under second course of toxins	Well, 1915; 7 years.
15 I.....	27	F	1907	Inguinal glands	No	4 months duration	Sarcoma	.....	First operation June 20, 1907; Dr. Moschcowitz; referred to me for toxin after-treatment by Dr. Gerster	Toxins few weeks, little effect	Not traced.
16 R.....	48	M	1913	Inguinal glands	10 years ago infection left groin	Noticed tumor, end of July, 1913	Sarcoma	Lymphosarcoma (Mt. Sinai Hospital)	First operation Nov. 11, 1914	Rapid local recurrence	Not traced.
17 P.....	7	M	1910	Inguinal glands	Groin kick	3 months	Sarcoma	No microscopical examination	First operation Oct., 1910, recurred, quickly	Toxins 3 weeks; tumor broke down; curetted and drained	Well 4 years later.

SARCOMA OF RETROPERITONEAL AND MESENTERIC GLANDS

	Name	Age	Sex	Date	Locality	Antecedent trauma or infection	Duration	Diagnosis, clinical	Diagnosis, microscopical	Treatment	Result, immediate	Result, final
1	W.....	25	F	Oct., 1903	Mesenteric glands, small intestine	No	Few months	Sarcoma, inoperable	Round-celled sarcoma, Prof. W. F. Whitney, of Harvard Medical School	Toxins, 4 months	Entire disappearance; fecal fistula developed	Recurred Jan., 1905; died, fall, 1905.
2	H.....	48	F	Feb., 1911	Mesenteric glands	No	First noticed Jan., 1909	Tumor	Round-celled sarcoma	5 operations, Presbyterian Hospital, Dr. E. Eliot	Large inoperable tumor; abdomen filled when toxins tried for brief period; little effect	Death, 1911.
3	P.....	45	M	Oct., 1895	Retroperitoneal glands	No, followed "grippe"	1 year	Tumor, malignant	Round-celled sarcoma	Toxins 6 weeks	Inoperable; temporary decrease in size	Later grew rapidly; died Jan., 1896.
4	G.....	41	M	Nov., 1907	Mesentery and small intestine	No	3 months	Malignant tumor	Round-celled sarcoma	Exploratory laparotomy; specimen removed	.....	Died, few months.
5	X.....	30	F	Feb., 1907	Mesenteric and retroperitoneal	No	2 months	Malignant tumor	Lymphosarcoma	Exploratory operation; specimen removed	Feb. 9, 1907, abdomen filled with tumor, extreme emaciation, no treatment	Died in few weeks.
6	G.....	32	M	June, 1901	Small intestine mesentery	Fall, April, 1901; pain soon after	2 months	Sarcoma	Lymphosarcoma	Exploratory laparotomy, specimen removed	Rapid growth	Death, few months later.
7	B.....	50	M	Sept., 1904	Mesentery small intestine	No	Few months	Sarcoma	Round-celled sarcoma	Exploratory laparotomy; removal tumor; X-ray after the operation, also mixed toxins	Well 2½ years, then recurred; toxins given 3 months; slight improvement; later little effect; second operation Nov., 1907, followed by toxins; gained 12 pounds	Dec., 1907, died of shock following third operation.
8	J.....	23	F	Aug., 1894	Mesentery and small intestine	No	Few months	Malignant tumor	Round-celled sarcoma (German Hospital, Dr. Willy Meyer)	Exploratory laparotomy; specimen removed for microscopical examination	Mixed toxins, 5 months; entire disappearance of tumor	Patient well 12 years later.

SARCOMA OF RETROPERITONEAL AND MESENTERIC GLANDS—*Continued*

Name	Age	Sex	Date	Locality	Antecedent trauma or infection	Duration	Diagnosis, clinical	Diagnosis, microscopical	Treatment	Result, immediate	Result, final
9 M.....	..	F	July, 1914	Mesenteric	No	Few months	Malignant tumor; rapid recurrence	Spindle-celled sarcoma or fibroma	2 operations in 6 months	Toxins, 1 year with intervals of rest	Well Aug. 1, 1915, more than 1 year.
10 K.....	25	M	March, 1912	Retroperitoneal glands, with probable involvement of iliac glands	No	3 months	Sarcoma	Sarcoma; no evidence of tuberculosis	Inoperable; toxins 2 months	At end of 4 weeks the tumor became fluctuating and an incision was made and several ounces of fluid and broken down tumor evacuated; sinus continued	Well Nov., 1915, 3 years later. Sinus curetted Nov. 15, 1915. Diagnosis of tuberculosis in mild form, made from inoculation of guinea-pig with pus.

HODGKIN'S DISEASE

Name	Age	Sex	Date	Locality	Antecedent trauma or tonsillitis	Duration	Diagnosis, clinical	Diagnosis, microscopical	Treatment	Result, immediate	Result, final
1 K.....	24	M	Oct., 1907	Neck, axillary glands; inguinal glands, spleen and groin	No	1 year, loss of weight, 20 pounds	Typical Hodgkin's	Hodgkin's (Dr. Ewing)	Mixed toxins	Entire disappearance in 5 weeks of all visible or palpable lesions; refused to continue treatment; recurrence in 7 months	Death 1 year lat
2 C.....	29	M	1910	Inguinal region; iliac fossa and liver	No	2 years, 4 months	.....	Blood picture not typical of Hodgkin's; autopsy, Dr. Ewing; typical Hodgkin's	Toxins for several weeks	Only temporary improvement	Death, 1910; autopsy showed invasion of bone and muscle spine.
3 E.....	34	M	1909	Neck	No	2 years, 20 pounds loss in weight	Hodgkin's	.....	.....	.....	Death.
4 N.....	25	F	1905 1908	Neck and axilla, spleen not enlarged	No	2 years	Hodgkin's	Gland examined, typical Hodgkin's (Ewing); guinea-pig inoculations, negative	1905, 10 X-ray and 9 toxin treatments; operation, 1908	Temporary improvement	Not known.
5 T.....	21	M	1907	Neck (1905)	No	1 year	Hodgkin's	Glands examined, Bender laboratory; typical Hodgkin's	Toxins (Coley)	Considerable temporary improvement	Not traced.

6	B.....	43	M	1902	Submaxillary glands, neck; later axilla, groin, spleen, liver	Trouble with molar tooth, 3 years before; mastoiditis, 1 year before	Spring, 1902, after severe cold	Typical Hodgkin's	Microscopical examination, Hodgkin's	Toxins, later X-ray; see full history	Marked temporary improvement	Died spring, 1903.
7	S.....	6	M	1907	Neck, axilla, groin	No	Duration of disease, 3½ years	.....	Typical Hodgkin's	Operation, Roosevelt Hospital, 3 years before; toxins 4 months	No effect	Death, 1908.
8	R.....	28	M	1907	Neck	No	3 years	Typical Hodgkin's	Hodgkin's, Dr. F. C. Wood	.....	.....	Not traced.
9	S.....	50	F	1907	Neck, axilla, groin, spleen, liver	No	.....	Sarcoma	Lymphatic leukæmia (630,000 white cells)	X-ray, 10 months Accidental erysipelas, May, 1907 Mixed toxins, Sept., 1907; second attack erysipelas Jan., 1908	Temporary improvement Marked improvement Marked improvement	Was not traced.
10	C.....	24	M	July, 1911	Neck	.....	1 year	Lymphosarcoma	Hodgkin's disease or carcinoma	Portions of tumor removed for microscopical examination	Toxins, 2 weeks; little effect	Rapid progress; died in few months.
11	D.....	47	M	1913	Neck	No	4 months	.....	Round-celled sarcoma, first and second operations; atypical Hodgkin's after third operation (Ewing)	First operation, recurrence; toxins and X-ray after second operation; third extensive operation, Jan., 1914	Temporary improvement only	Death May, 1914.
12	R.....	25	F	1907	Neck, spleen, liver, axilla, groin	No	2 years	Clinical diagnosis and blood examination	.....	.....	.....	Death.
13	S.....	56	M	1908	Neck, liver	Following attack of tonsillitis	8 months	Hodgkin's	Hodgkin's	Toxins, several months	Temporary decrease in size and improvement, general condition	Died few months later.
14	M.....	37	M	1906	Groin	No	3 years	Hodgkin's	Typical Hodgkin's disease; blood, 51,000 white blood cells, 4,200,000 red	Very extensive operation Aug., 1906 (Dr. Downes); tumor, size of 2 fists. Beebe's nucleo-proteid serum for Hodgkin's	No effect, rapid recurrence; toxins, little effect	Died few months later.

HODGKIN'S DISEASE—*Continued*

Name	Age	Sex	Date	Locality	Antecedent, trauma or tonsillitis	Duration	Diagnosis, clinical	Diagnosis, microscopical	Treatment	Result, immediate	Result, final
15 K.....	55	F	1913	Neck	.....	10 years	.....	First operation, tumor not examined; second, lymphosarcoma, Bellevue laboratory; third, typical Hodgkin's (Dr. Ewing)	3 operations and toxins following last operation	Marked decrease in size under toxins; later increase; again glands removed; rapid recurrence; X-ray, marked improvement	Not traced, getting worse when last seen.
16 M.....	29	M	April, 1914	Neck	.....	3½ years	Hodgkin's, one large mass on each side of neck	.....	No treatment	.....	Not traced.
17 Z.....	29	M	1914	Tonsil and neck	Following attack of tonsillitis	Less than year	Lymphatic leukaemia, lymphosarcoma	Lymphatic leukæmia	Vaccines, X-ray; mixed toxins, streptococcus and staphylococcus	No improvement	Death within 9 months from onset of disease.
18 B.....	65	M	June, 1913	Neck.	Cut finger 4 months previously, wound did not heal well	10 weeks	Hodgkin's disease	.....	X-ray, 35 treatments, and vaccine treatment	Improved	Not known.
19 E.....	49	F	March, 1915	Submaxillary and axillary glands	.....	4 years	Hodgkin's disease	Pseudoleukæmia, later changing into leukæmia	X-ray treatment	Marked decrease in size of all tumors, but general health deteriorating	Still under treatment.
20 R.....	62	M	Aug., 1915	Groin	Negative	Few months	Hodgkin's—typical fever of Hodgkin's	Hodgkin's or lymphosarcoma, unable to determine which	Few X-ray treatments	Very rapid loss of flesh and strength, with extension into other glands	Died Sept., 1915; autopsy showed very extensive involvement of lymph-gland.
21 P.....	12	M	June 11, 1915	Axilla	No	9 weeks, small movable tumor, right axilla	Hodgkin's	Microscopical examination showed spindle-celled sarcoma	Tumor in axilla removed 4 weeks after first noticed; quick recurrence in cervical, axillary and retroperitoneal; irregular fever	Rapid improvement under X-rays followed by rapid generalization of disease	Died Aug. 15, 1915—duration of disease, 4 months.

TABLE OF CASES SUCCESSFULLY TREATED BY OTHER SURGEONS

While most of these patients were treated under my direction, I have thought it best to place them in a separate table.
Most of these cases have been reported more fully in medical journals, the references to which are given. The histories of the other cases have been sent me by the surgeon who treated them.

CASES OF OTHER MEN, SUCCESSFULLY TREATED WITH THE MIXED TOXINS

No.	Name of surgeon and reference	Sex	Age	Date	Locality	Type of tumor	Treatment, duration	Result, immediate	Result, final
1	Dr. Herman Mynter..... Medical Record, Feb., 1905	M	adult	1895	Intra-abdominal, involving cæcum, omentum and mesentery	Spindle-celled	Toxins, 2 months	Entire disappearance	Patient well, 4 years later.
2	Dr. H. L. Williams..... Rochester, N. Y.; personal communication	F	..	1896	Sarcoma, intra-abdominal; mesentery	Spindle-celled	4 weeks	Entire disappearance	Patient well December, 1913; 17 years.
3	Dr. Chas. R. Barber..... Rochester, N. Y.; personal communication	M	35	1894	Intra-abdominal, very extensive, involving mesentery and omentum	No microscopical examination, but recurrent	Unfiltered toxins (Buxton)	Entire disappearance	Patient alive and well, December, 1913; 18½ years.
4	Dr. Horace Packard..... Boston, Mass.; "Five years in Surgery" and personal communication	F	55	May, 1896	Inoperable, intra-abdominal, sarcoma; retroperitoneal	Spindle-celled	Toxins unfiltered	Entire disappearance	Patient well 2 years later.
5	Prof. J. Collins Warren..... Boston; Boston Medical and Surgical Journal, Dec. 26, 1896	M	adult	1896	Neck, recurrent	Round-celled	Toxins. unfiltered (Buxton)	Entire disappearance	Recurrence, 6 months later.
6	Dr. H. A. Matagne..... Medical de Liege, May 14, 1896	..	..	1895	Neck	Sarcoma (recurrent)	Toxins unfiltered, 3½ months	Entire disappearance	Slight recurrence in 6 months, not traced thereafter.
7	Ibid.....	..	..	1895	Neck, tumor size of fetal head	Sarcoma (recurrent)	Toxins unfiltered, 3 months	Decreased two-thirds	Died of shock following operation to remove the remainder.
8	Mr. W. H. Battle..... St. Thomas Hospital, London; Lancet, April 9, 1898	M	30	June, 1897	Multiple-, infra-, and supra-clavicular and pectoral regions and axilla	Fibrosarcoma, spindle-celled; microscopic examination by Dr. Shattock	Toxins, unfiltered, 4 months	Almost complete disappearance	Patient shown to Medical Society of London, nearly one year later.
9	Dr. F. H. Zabriskie..... Greenfield, Mass.; personal communication	F	40	1896	Intra-abdominal, recurrent; retroperitoneal	Spindle-celled	Toxins unfiltered (Buxton), 1 year	Tumor disappeared	Patient well, 12 years later.
10	Dr. John O. Roe..... Rochester, N. Y., personal communication	M	Adult	May, 1894	Neck and tonsil, recurrent	Adenosarcoma, round-celled	Toxins unfiltered (Buxton)	Tumor improved rapidly; had almost entirely disappeared when 6 months later developed erysipelas of scalp, which proved fatal	Died of erysipelas.

TABLE OF CASES SUCCESSFULLY TREATED BY OTHER SURGEONS—*Continued*

No.	Name of surgeon and reference	Sex	Age	Date	Locality	Type of tumor	Treatment, duration	Result, immediate	Result, final
11	Dr. O. C. Davies..... Augusta, Me.; personal communication	..	Adult	April, 1901	Neck (recurrent)	Mixed-celled; large, round and spindle	Mixed toxins (Buxton)	Tumor, one-half size of egg involving deep structures of neck; entire disappearance	Patient well 11 years.
12	Dr. O. W. Roberts..... Springfield, Mass.; personal communication	F	40	1901	Intra-abdominal, probably retroperitoneal; size of child's head	No microscopic examination; patient experienced much pain	Mixed toxins, several months; Parke-Davis & Co. preparation	Entire disappearance; examined by Dr. Coley, October, 1905	Well, Sept., 1915, 14 years.
13	Ibid.....	..	..	1899	Intra-abdominal	Sarcoma confirmed by microscopic examination	Mixed toxins, exploratory laparotomy	Entire disappearance	Well, Sept., 1915; 15 years.
14	Ibid.....	..	..	....	Intra-abdominal	Sarcoma confirmed by microscopic examination	Mixed toxins, exploratory laparotomy	Entire disappearance	Well when last heard from, over 3 years later.
15	Dr. Tritch..... President North Western Medical Society, of Ohio; personal communication	M	62	1912	Inguinal and iliac glands, twice recurrent	Lymphosarcoma, round-celled	Toxins, 3–4 months	Gradual and complete disappearance	Letter from Dr. Tritch, Jan. 29, 1914, states "patient is in good health without recurrence, more than 1½ years.
16	Dr. C. E. Preston..... Ottawa, Canada; personal communication	M	19	June, 1908	Typical Hodgkin's; glands in neck, axilla and groin; enlarged spleen and liver	Hopeless prognosis given by staff of Ottawa General Hospital	Toxins begun June 1, 1908, and continued 6 months	Immediate local and general improvement; gain of 23 pounds in six months; palpable lesions disappeared	Patient in good health, Sept. 1, 1915, 7 years later.
17	Drs. Crile, Stanton, McMullen, and Coley Surgery, Gynecology and Obstetrics, Aug. 11, 1911	M	35	Feb., 1910	Tonsil and glands of neck	Small, round-celled sarcoma; microscopic examination by Dr. Geo. W. Crile, Dr. James Ewing and others	Tumor pronounced inoperable by Dr. Crile; toxins advised	Almost complete disappearance in 5 weeks; injections cut down to 5 a month, end of 5 weeks tonsils again enlarged to twice normal size; microscopic examination again, R. C. sarcoma; 15 injections of toxins in September	Entire disappearance of tumor; doses again cut down; recurrence; toxins showed less and less effect; rapid growth; death; Feb. 7, 1912 complete autopsy, no metastases.
18	Dr. F. B. Benham..... Syracuse, N. Y.; personal communication	F	Adult	1911	Intra-abdominal, involving mesentery and intestines	Sarcoma, inoperable (microscopic examination)	Exploratory laparotomy; case regarded as hopeless; toxins several months	Entire disappearance	Well 1½ years later.

19	Major C. G. Spencer..... Royal Army Medical Corps, London Lancet, Dec. 21, 1912; personal communication	M	25	July, 1912	Neck	Lymphosarcoma, microscopic examination (round-celled)	First operation March 6, 1912; rapid recurrence; second operation March 29, 1912, whole left side of neck filled with enlarged glands	Incomplete operation, March 29, 1912; rapid recurrence; toxins begun April 6, 1912 (Parke-Davis preparation), doses daily beginning M. ½ –M. 10; all injections local	2 months' treatment; entire disappearance in 6 weeks, treatment one month longer M. 10 alternate days, total 150 minims; perfect health 1 year later.
20	Dr. David S. Runnels..... Appleton, Wis.; personal communication	M	39	Feb., 1911	Intra-abdominal, right side; mesentery	Sarcoma (clinical diagnosis)	Exploratory laparotomy; tumor 6 inches in diameter; inoperable; no microscopic examination; toxins begun March, 1911	Doses M. ¼ to M. xv made mostly into tumor; slow but steady improvement; toxins kept up nearly 2 years	Entire disappearance of tumor; gain of 45 pounds in weight; patient in good health Oct., 1913 —2½ years.
21	Dr. Geo. H. Muller..... Philadelphia University, Pa. Hospital; Transactions Philadelphia Medical Society, ANNALS OF SURGERY, Feb., 1910	M	..	1907	Neck; recurrent in one month; inoperable	Lymphosarcoma, microscopic examination by pathologist of University Hospital	Toxins, no other treatment	Complete recovery	Patient well 4 years later, 1 month thereafter suddenly showed local recurrence and intra-abdominal metastases.
22	Dr. Arthur D. White..... Ithaca, N. Y.; personal communication	F	Adult	Dec., 1912	Ovary, with involvement of mesentery and intestines	Adenocarcinoma, microscopic examination, Dr. James Ewing	Incomplete removal by Dr. Robert T. Morris, early Dec., 1912; quick recurrence, rapid growth; general condition, poor; toxins begun Dec. 30, 1912; advised because original diagnosis was sarcoma	Immediate improvement which continued until complete disappearance by April, 1913	Patient well Dec., 1913, 1 year later, no recurrence.
23	Dr. M. E. Green..... American Journal of Homœopathy, Dec., 1907; personal communication	M	Adult	1907	Neck, lymphosarcoma; 4 times recurrent	Round-celled	Toxins, several months	Entire disappearance	Patient well over 3 years.
24	Dr. M. E. Green..... American Journal of Homœopathy, Dec., 1907; personal communication	M	Adult	1907	Neck, lymphosarcoma; 4 times recurrent	Round-celled	Toxins, several months	Entire disappearance	Patient well over 3 years.
25	Dr. J. D. Griffith..... Kansas City; personal communication	..	..	....	Neck, inoperable	Sarcoma, microscopic examination	Toxins	Recovery	Well over 3 years.
26	Ibid.....	..	..	....	Neck, inoperable	Sarcoma, microscopic examination	Toxins	Recovery	Well over 3 years.

TABLE OF CASES SUCCESSFULLY TREATED BY OTHER SURGEONS—*Continued*

No.	Name of surgeon and reference	Sex	Age	Date	Locality	Type of tumor	Treatment, duration	Result, immediate	Result, final
27	Ibid	..	..	....	Neck, inoperable	Sarcoma, microscopic examination	Toxins	Recovery	Well over 3 years.
28	Ibid	..	..	....	Neck	Sarcoma, microscopic examination	Toxins	Recovery	Well over 3 years.
29	Dr. W. L. Rodman, Prof. Surgery, Medico-Chirurgical College, Philadelphia; personal communication	M	Adult	1897	Tonsil and pharynx	Sarcoma, microscopic examination; recurrent after 4 months	Entire disappearance under toxin treatment	Complete recovery	Patient well 16 years later.
30	Dr. J. H. Glass, Utica, N. Y.; personal communication	M	19	1905	Neck	Small, round-celled sarcoma (recurrent)	2 operations; toxins one year	No recurrence, entire disappearance	Patient in good health 8 years after.
31	Dr. Cruikshank, Alex., Salem, Ohio; personal communication	M	Adult	1913	Retroperitoneal glands	Sarcoma, no microscopic examination	Exploratory operation, colostomy; mixed toxins 4 months	Decrease in size of tumor; patient gained in weight	1½ years later, entire disappearance, perfect condition 1½ years later.
32	Dr. Jos. Grindon, St. Louis, Mo.	F	50	1897	Neck, recurrent in thoracic wall	Spindle-celled sarcoma	Operation, incomplete; prompt recurrence; toxins after recurrence	Disappearance under 5 months' treatment with the toxins, Feb., 1898, recurrence in thoracic wall; operation followed by toxins	Patient then remained free from recurrence until death, eight years later, due to an acute pulmonary condition.
33	Dr. Percy Shields, Cincinnati, Ohio	F	48	1913	Tonsil and neck	Myxosarcoma	Toxin treatment from Sept. 28, 1913, to Dec. 31, 1914	Complete disappearance under 3 months' treatment	Patient well at present, nearly 2 years later.
34	Dr. Reginald Fitz, New York City (?)	M	5	....	Neck	Non-malignant (Dr. Ewing)	Toxins	Tumor continued to increase in size	Death 3 months later.
35	Dr. A. Jacoby, New Orleans, La.	M	58	1912	Inguinal glands	Small, round-celled sarcoma	Incomplete operation by Dr. F. W. Partram, New Orleans, La.; toxins by Dr. Jacoby, under my direction	Began to improve; entirely well July 13, 1912	Patient still well, June, 1915; 3 years.
36	Dr. J. H. Glass, Utica, N. Y.	F	19	1905	Neck	Small, round-celled sarcoma	First operation by Dr. Marshall, Feb. 28, 1906; March 13, 1906, operation by Dr. J. H. Glass, Utica, N. Y., followed by toxins	.....	Patient in good health when last heard from, Feb. 11, 1914; 8 years later.

CONCERNING THE SURGICAL ANATOMY OF THE THYROID WITH SPECIAL REFERENCE TO THE PARATHYROID GLANDS*

By Eugene H. Pool, M.D.
of New York
Attending Surgeon to the New York Hospital; Consulting Surgeon to the French Hospital New York
and
Henry C. Falk, M.D.

Certain steps in the operative procedures which are employed as routine in the surgery of the thyroid gland may be attended by confusion if the operator lacks an exact knowledge of the anatomy of the parts involved. Thus, in connection with the operation of excision of a lateral lobe, considerable uncertainty prevails as to the relationship of the surgical capsule, the parathyroid glands and the recurrent laryngeal nerve to the posterior part of the lobe. The consideration of these essential anatomical details, as they bear upon the operation of lobectomy, is the basis of this paper.

Excision of Lobe.—The removal of a lateral lobe of the thyroid gland is frequently indicated in the surgical treatment of simple goitre and exophthalmic goitre. The extirpation of the lobe as usually practised is intracapsular, that is, the lobe is shelled out of the surgical capsule, which is a connective-tissue envelope formed from the deep cervical fascia (Fig. 1). All surgeons recognize the importance of careful dissection at the posterior aspect of the lobe in order to avoid injury to the recurrent laryngeal nerve and to safeguard the parathyroid glandules. Yet there is divergence of opinion and of practice as to whether the extirpation should include the posterior part of the lobe or whether a layer of thyroid tissue should be left in this region (Fig. 2). The latter procedure offers a greater degree of protection to the inferior laryngeal nerve and to the parathyroid glands; but it results in more hemorrhage, which in some cases is difficult to control; moreover, it prolongs the operation and leads to greater post-operative exudate.

The present study was undertaken primarily to determine whether the theoretical advantages of leaving a portion of the posterior part of the lobe, that is, the part in relation with the recurrent laryngeal nerve and the parathyroid bodies, have sufficient anatomical basis to outweigh the practical disadvantages of the procedure. With this object in view,

* Read before the New York Surgical Society, October 27, 1915, and the Chicago Surgical Society, November 5, 1915.

an effort has been made to trace the course and to establish the relations of the surgical capsule in the posterior region of the lobe and to determine the relationship of the parathyroids and the recurrent laryngeal nerve to this fascia and to the thyroid itself.

Surgical Capsule.—Transverse sections of the neck were made from three cadavers. The drawing (Fig. 3), which may be considered typical, shows the general arrangement of the fascial planes.

Several features in the gross sections are worthy of note. First, the surgical capsule in the non-goitrous neck is not as well marked as might be expected from the conditions noted in operations upon goitrous glands. However, it is fair to assume that the difference in the fascial planes around a normal and a goitrous thyroid is merely one of degree. In other words, although the surgical capsule may be thicker and better marked around a goitrous than a normal thyroid the structural details and arrangement are essentially the same. Second, the sheath of the great vessels is closely associated with the surgical capsule of the thyroid. This feature is corroborated by microscopic sections (Figs. 4 and 5). *Third, the surgical capsule at the posterior aspect of the lobe divides into two layers,* one, relatively dense, passes posterior to the œsophagus to enter into the formation of the prevertebral fascia; the other passes forward and mesially to the postero-external aspect of the trachea. *This layer is of especial importance, since it constitutes the surgical capsule in this region.* It consists of a thin dense layer closely apposed to the thyroid (Figs. 6, 7 and 8).

The separation of the surgical capsule into two layers, as just described, is of considerable importance. In the normal (non-goitrous) neck this separation defines a triangular area bounded by these two fascial layers and, mesially, by the œsophagus. This space contains loose areolar tissue and in it lies the *recurrent laryngeal nerve* (Figs. 3 and 6). When the thyroid enlarges the space may be obliterated, in which case the two layers lie in apposition. Certain anatomical details which bear directly upon the operation of lobectomy are thus made clear. They may be summarized as follows: There is a continuation of the surgical capsule in the posterior region of the lobe; outside of this fascial layer lies the recurrent nerve which is consequently safeguarded in a true intracapsular extirpation of a lobe. However, it is evident that in the performance of an intracapsular extirpation, or lobectomy, the capsule is likely to be torn in the region of its division into the two layers; the operator then follows the posterior layer in the dissection and the cellular plane between the two layers is entered and the recurrent laryngeal nerve is endangered.

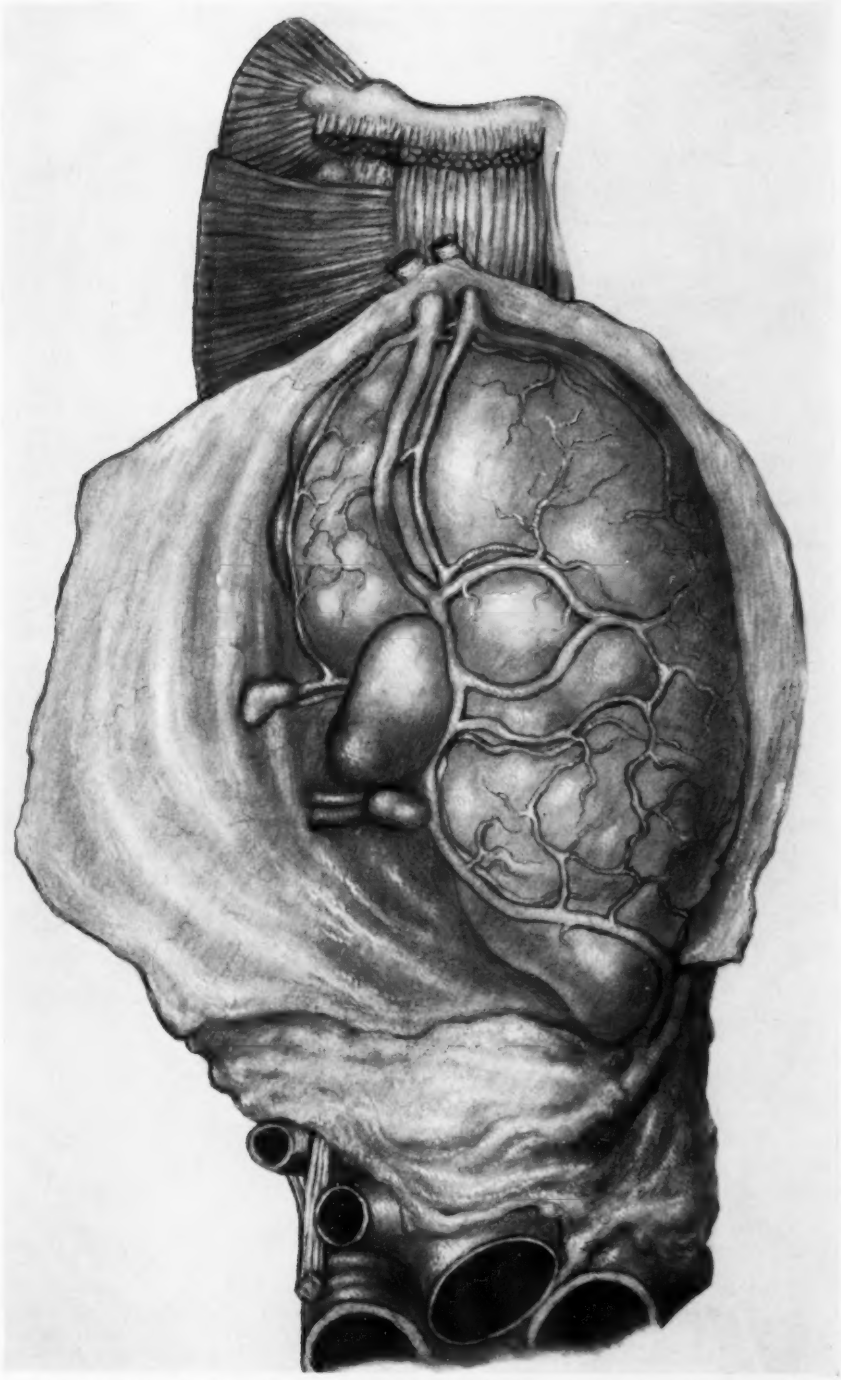


FIG. 1.—Autopsy specimen from patient with exophthalmic goitre, showing the capsule cut and stripped from the right lobe, the lobe being drawn forward so as to expose the structures in relation with its posterior surface. The relations of the parathyroids to the inferior thyroid artery and capsule are of particular interest in this specimen. The superior parathyroid stripped off readily with the capsule, the inferior did not strip off and was left in close contact with the thyroid and the lower branch of the inferior thyroid artery.

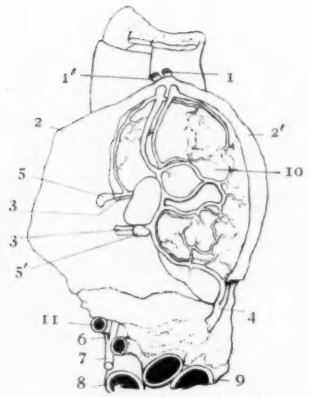


FIG. 1a.—1, superior thyroid artery; 1′, superior thyroid vein; 2, 2′, surgical capsule stripped from the gland; 3, branches of inferior thyroid artery with accompanying veins; 4, inferior thyroid veins; 5, superior parathyroid; 5′, inferior parathyroid; 6, recurrent laryngeal nerve; 7, vagus nerve; 8, trachea; 9, aorta; 10, thyroid; 11, subclavian artery.

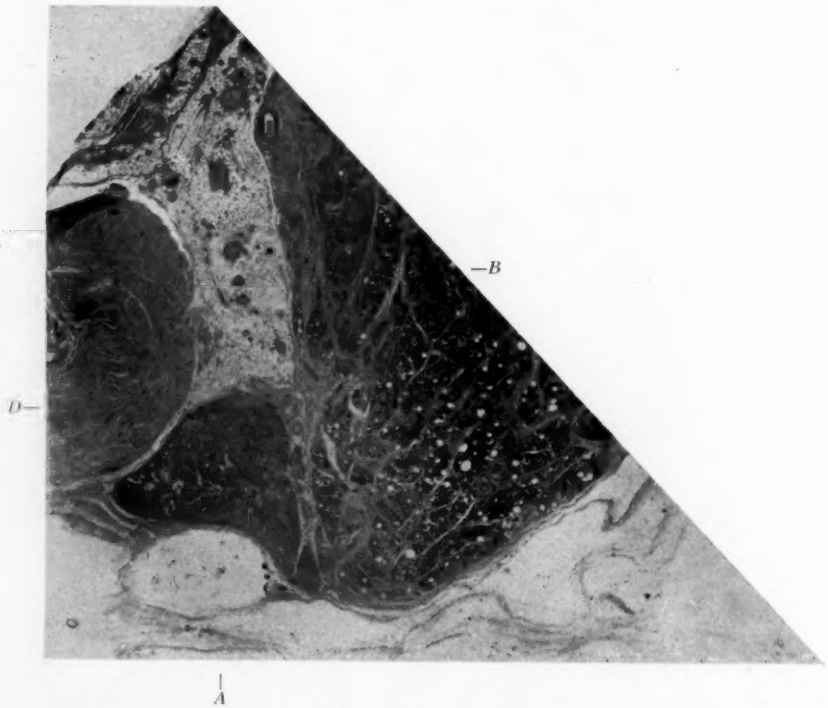


FIG. 2.—Approximate line of division when posterior part of lobe is left so as to safeguard the parathyroids and recurrent laryngeal nerve, of which four filaments may be seen between thyroid and œsophagus. *A*, parathyroid; *B*, thyroid; *D*, œsophagus (magnification, x15).

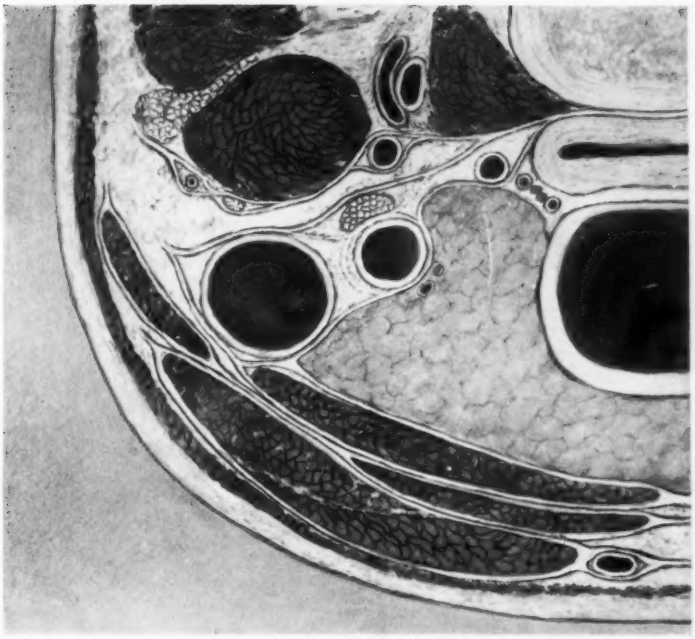


FIG. 3.—Transverse section of the neck at level of the middle of the seventh cervical vertebra showing general arrangement of the fascial planes.

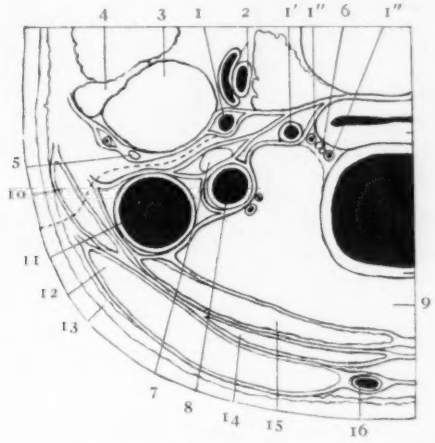


FIG. 3*a*.—Outline of Fig. 3. 1, 1′, 1″, inferior thyroid artery; 2, vertebral artery and vein; 3, scalenus anticus; 4, brachial plexus; 5, phrenic nerve; 6, recurrent laryngeal nerve; 7, vagus; 8, carotid artery; 9, thyroid; 10, omohyoid; 11, jugular vein; 12, sternomastoid; 13, platysma; 14, sternohyoid; 15, sternothyroid; 16, anterior jugular vein. Dotted line indicates approach for ligation of inferior thyroid artery by posterior method. (The operative approach is above the omohyoid, 10.)

FIG. 4.—Showing close relationship between the sheath of the great vessels and the surgical capsule of the thyroid. *A*, parathyroid; *B*, thyroid; *C*, recurrent laryngeal nerve; *E*, carotid; *F*, surgical capsule and carotid sheath.

FIG. 5.—Showing close relationship between sheath of the great vessels and the surgical capsule of the thyroid. *A*, parathyroid; *B*, thyroid; *E*, carotid; *F*, surgical capsule and carotid sheath.

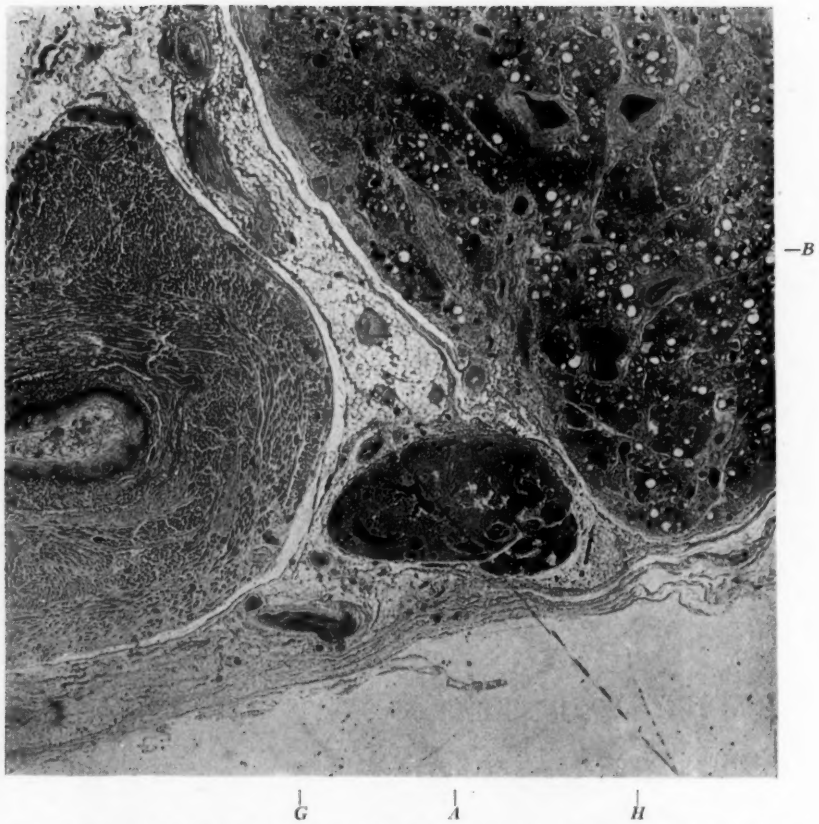


FIG. 6.—Division of the capsule into two layers at the posterior aspect of the lobe; cellular space, containing parathyroid and recurrent laryngeal nerve between these two layers. *A*, parathyroid; *B*, thyroid; *D*, œsophagus; *G*, high power of this area, Fig. 8; *H*, of Fig. 7.

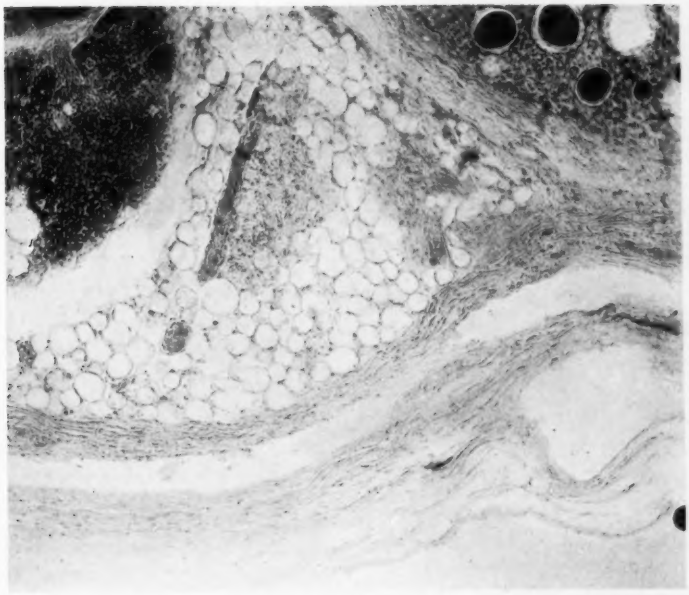


FIG. 7.—High power of Fig. 6, showing division of surgical capsule into two layers (magnification x120).

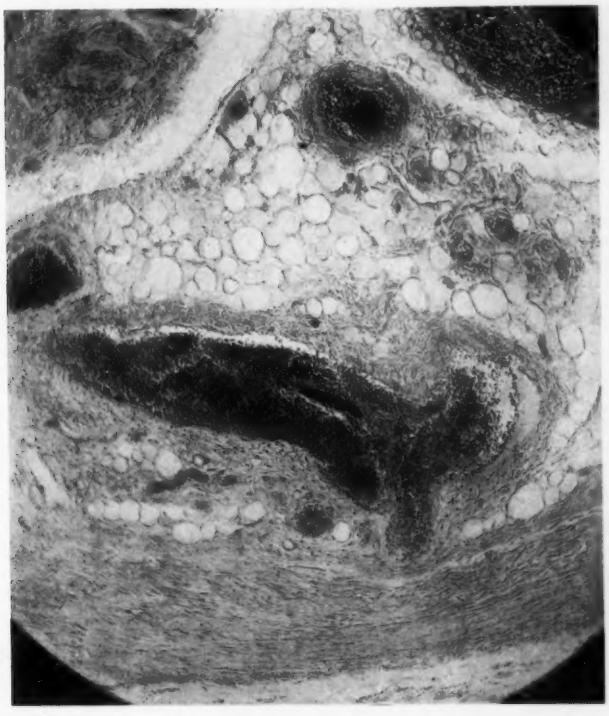


FIG. 8.—High power of Fig. 6, showing dense layer of connective tissue which passes posterior to œsophagus (magnification, x120).

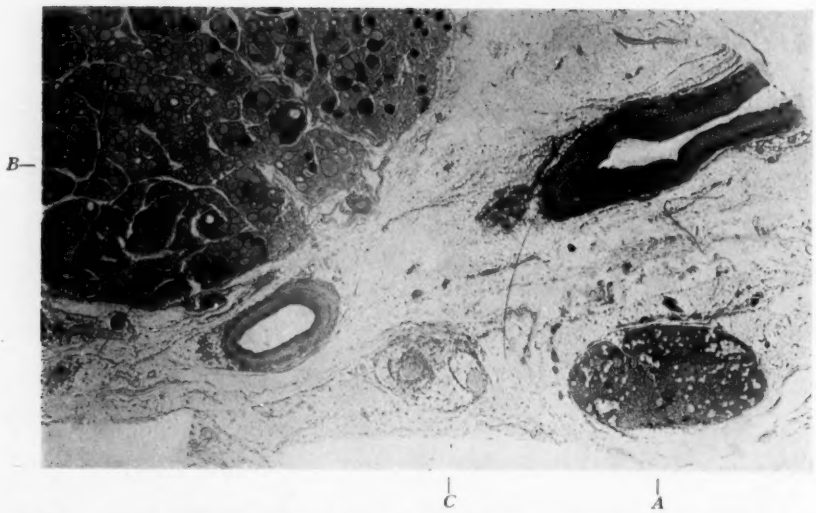


FIG. 9.—Parathyroid external to the capsule and at such a distance from the thyroid as to be safeguarded by an intracapsular operation. The nerve and branch of inferior thyroid artery lie between the parathyroid and the thyroid (Class I). *A*, parathyroid; *B*, thyroid; *C*, nerve.

FIG. 10.—Parathyroid external to the capsule and at such a distance from the thyroid as to be safeguarded by an intracapsular operation. The parathyroid lies between the nerve and the thyroid (Class I). *A*, parathyroid; *B*, thyroid; *C*, recurrent laryngeal nerve.

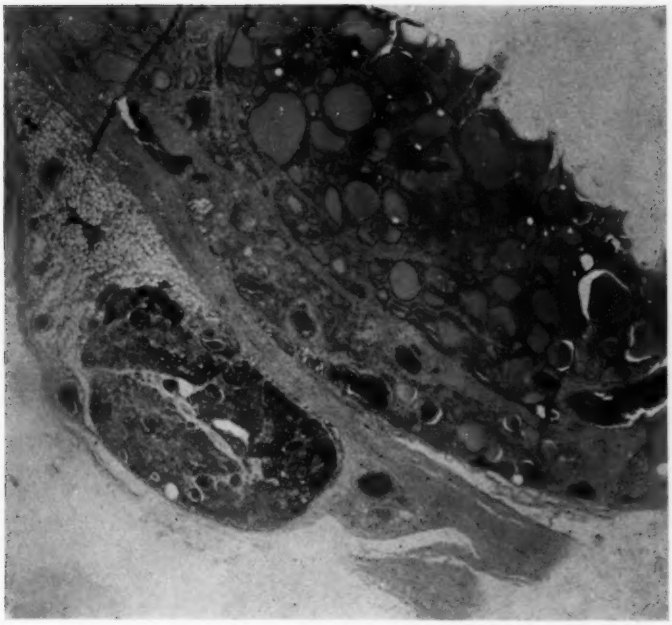


FIG. 11.—Parathyroid separated from thyroid by dense capsule.

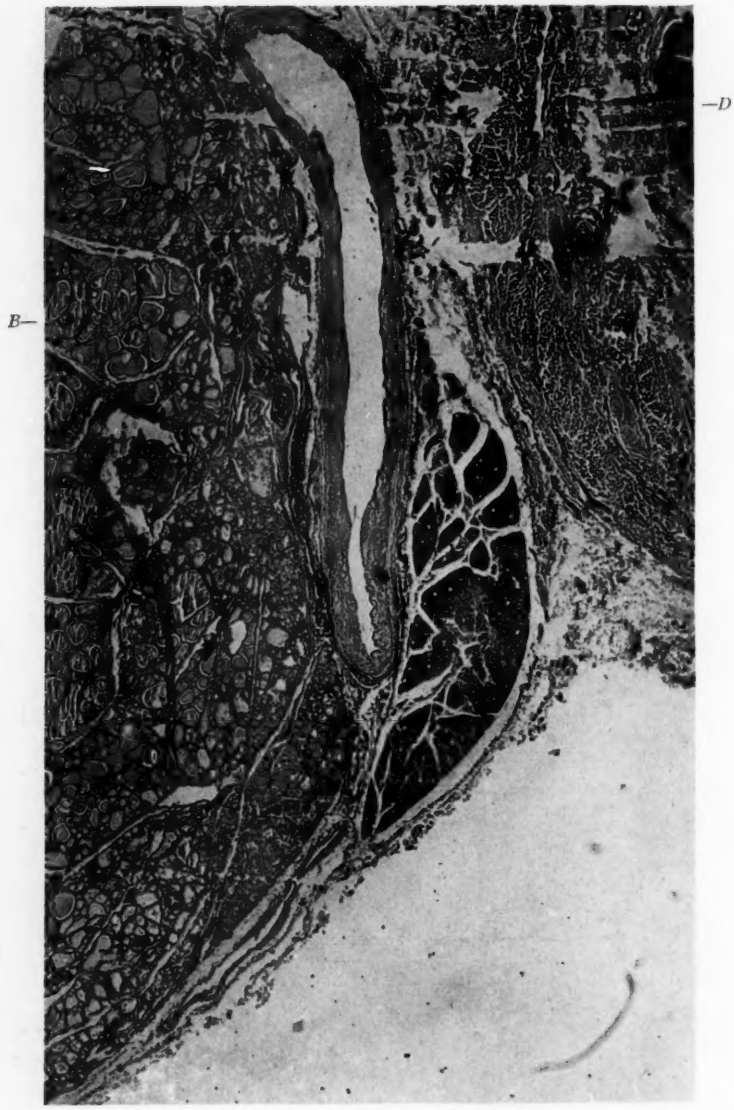


FIG. 12.—Parathyroid so close to thyroid that it might be endangered in an "intracapsular" removal of lobe (Class II).

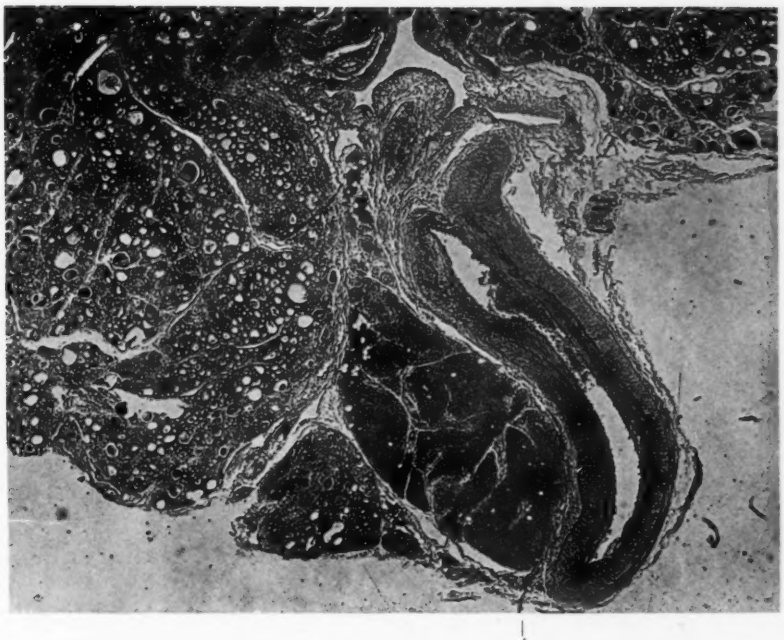


FIG. 13.—Parathyroid so close to thyroid that it would be endangered in an "intracapsular" removal of the lobe (Class II). *A*, parathyroid.

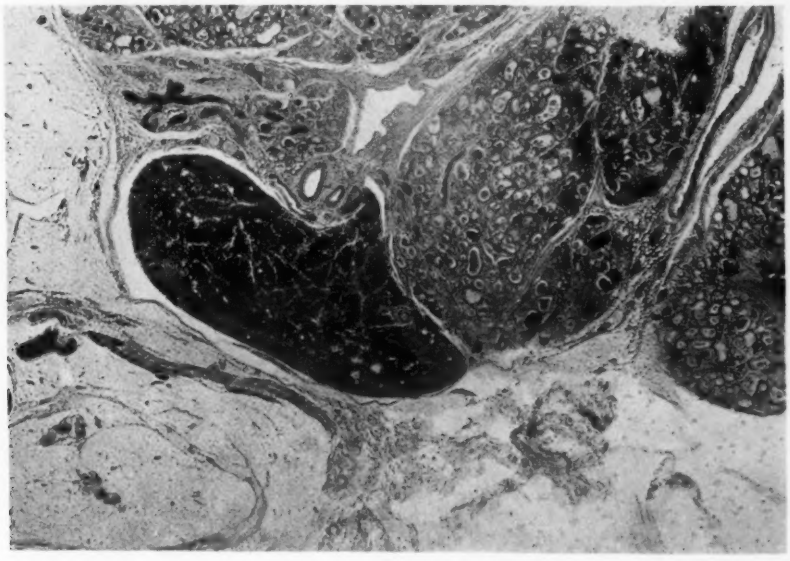


FIG. 14.—Parathyroid in such close relation to the thyroid that it would probably be removed with the lobe in an intracapsular lobectomy (Class III).

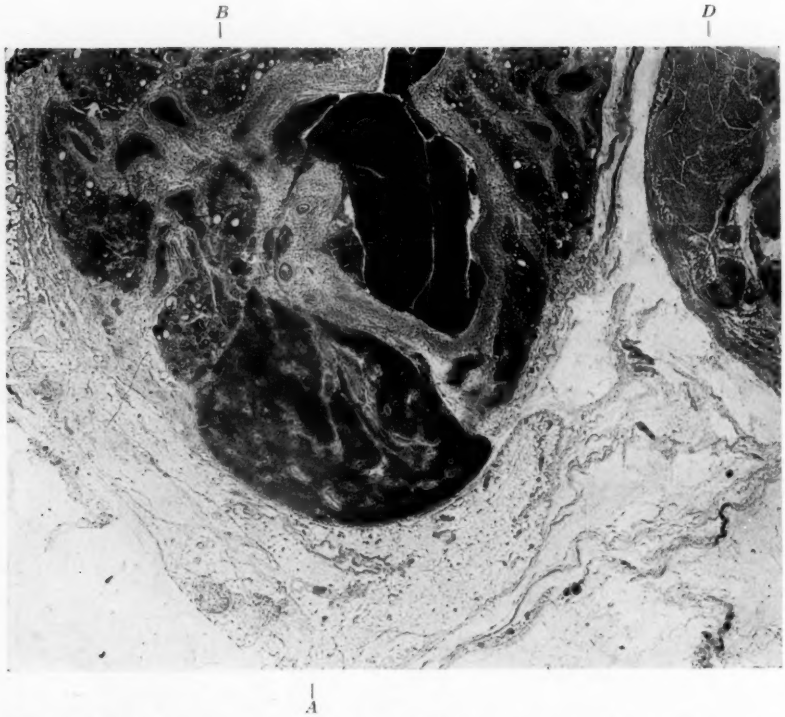


FIG. 15.—Parathyroid in such close relation to the thyroid that it would probably be removed with the lobe in an "intracapsular" lobectomy (Class III). *A*, parathyroid; *B*, thyroid; *D*, œsophagus.

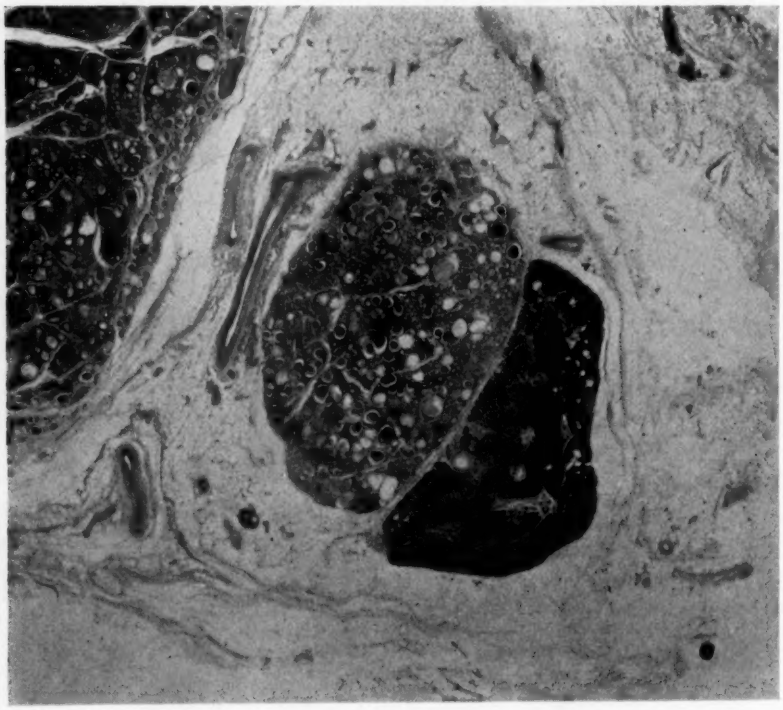


FIG 16.—Parathyroid in close relation to an accessory thyroid.

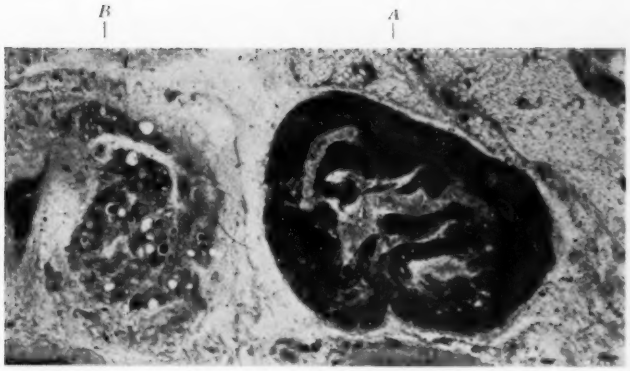


FIG. 17.—Parathyroid situated at and below the extreme lower pole of the thyroid lobe. *A*, parathyroid; *B*, thyroid.

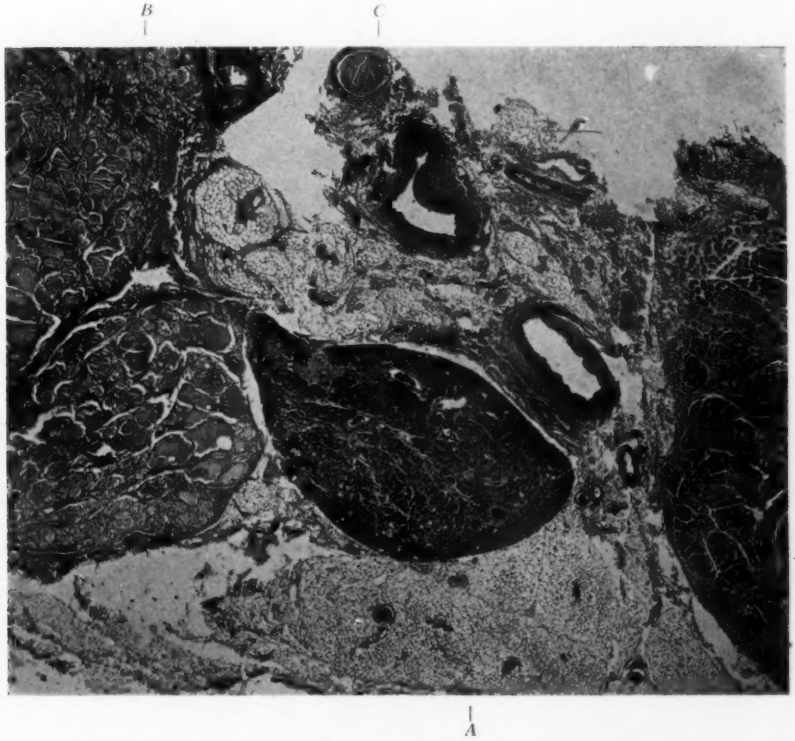


FIG. 18.—To contrast different relationships of thyroid, parathyroid, recurrent laryngeal nerve, inferior thyroid artery and œsophagus. Compare Fig. 19.

FIG. 19.—To contrast different relationships of the thyroid, parathyroid, recurrent laryngeal nerve, inferior thyroid artery and œsophagus. Compare with Fig. 18. *A*, parathyroid; *B*, thyroid; *C*, nerve; *D*, œsophagus.

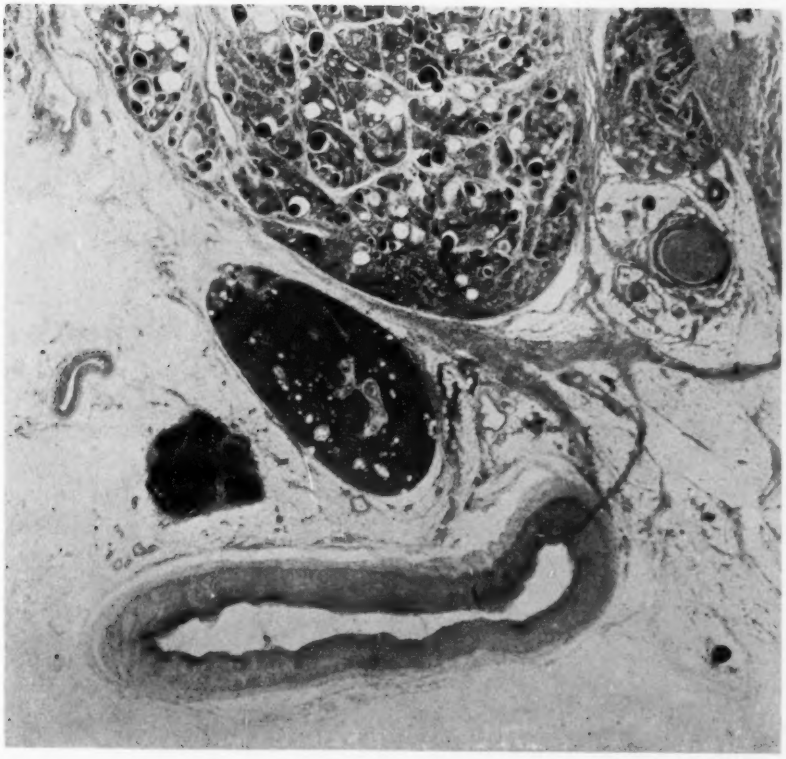


FIG. 20.—Parathyroid lying between branch of inferior thyroid artery and thyroid gland; separated from the latter by a dense layer of fascia.

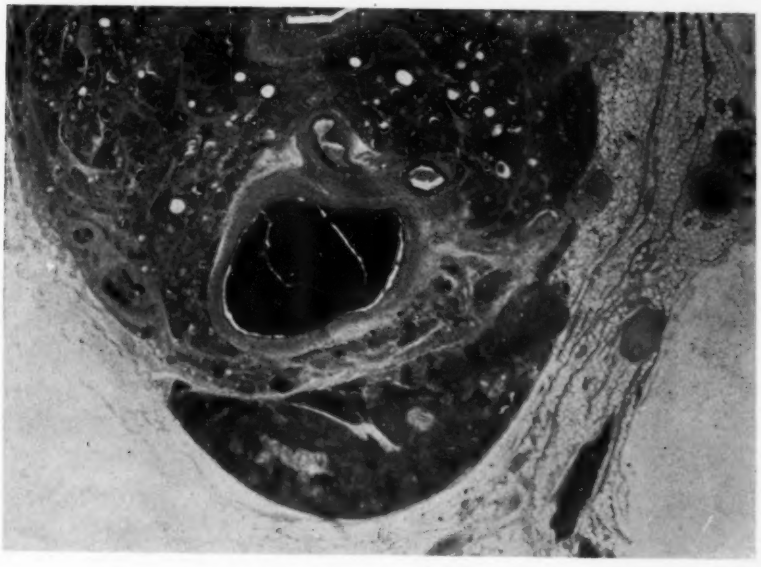


FIG. 21.—Showing parathyroid flattened out on side of thyroid.

The Topography of the Parathyroids.—The tissues of the neck anterior to the spine were removed at autopsy in 25 cases. They were cut transversely in thin layers and a search was made for the parathyroid glands. When tissue suggestive of a parathyroid was found it was blocked with the surrounding structures and sections were made for microscopic examination.

Sixty parathyroids were found and studied. They may be grouped as follows:

Class I. Those which lay external to the capsule at sufficient distance from the thyroid and in such a position as to be safeguarded in an intracapsular extirpation of the lobe. These numbered 26, or 43.3 per cent. (Figs. 9, 10 and 11).

Class II. Those whose relationship to the capsule and to the thyroid was such as to make it doubtful whether they would be saved in an intracapsular removal of the lobe. These were 9 in number, or 15 per cent. (Figs. 12 and 13).

Class III. Those whose position was such that they would almost certainly have been removed with the thyroid in an intracapsular extirpation of the lobe. These numbered 25, or 41.7 per cent. (Figs. 14 and 15).

Summary.—25 specimens sectioned for parathyroids; 60 parathyroids found:

TABLE I

0 parathyroid	2 cases
1 parathyroid	2 cases
2 parathyroids	10 cases
3 parathyroids	6 cases
4 parathyroids	5 cases
Right superior	12
Left superior	14
Right inferior	16
Left inferior	16
Right middle[1]	1
Not classified[2]	1

The occurrence of the parathyroid glands in pairs may properly be considered the typical arrangement, a superior and inferior body being present on each side. *Although variations in the anatomical positions are frequent,* it may be stated that the superior most often lies in relation to the middle third of the posterior border of the lateral lobe of the thyroid; the inferior in relation to the inferior third of the posterior

[1] Only three were found; all on one side.

[2] Only one was found in the first case studied; its situation was not recorded.

surface of the lobe or lower, even below the inferior pole. Accessory accumulations of characteristic parathyroid cells may be present, especially below the thyroid and within the thyroid (Getzowa). Such aberrant parathyroids probably prevent, in some cases, ill effects from the sacrifice of considerable parathyroid tissue.

In Table II the situation of each parathyroid relative to the surgical capsule is represented as follows:

Class I. Those which lay external to the surgical capsule in such a position as to be safeguarded in an intracapsular extirpation of the lobe ("I" in table).

Class II. Those whose relationship to the surgical capsule and to the thyroid make it doubtful whether they would have been saved ("II" in table).

Class III. Those whose relationship was such that they would almost certainly have been removed ("III" in table).

TABLE II

No. of specimen	Left superior	Left inferior	Right superior	Right inferior	Not classified
1	.....	.....	.....	.....	III[2]
2	.....	I	I	III	
3	I	II	.....	I	
4	.....	III	.....	III	
5	II	I	I	I	
6	I	.....	III	I	
7	III	III	III	III	
8	No parathyroids found				
9	.....	.....	I I[1]	I	
10	No parathyroids found				
11	III	I	III	I	
12	III	.....	III		
13	II	III	III	III	
14	II	III	III	II	
15	.....	I			
16	I	I			
17	.....	II	.....	II	
18	I	.....	III		
19	III	III	III		
20	II	.....	.....	III	
21	.....	II	.....	I	
22	.....	III	.....	I	
23	I	.....	.....	III	
24	.....	I	.....	I	
25	I	I	I		

Summary of Table II.—In a unilateral intracapsular removal of a lobe:

Left lobe: Two parathyroids would have been sacrificed (Class III) 2 times, or 8 per cent.; two parathyroids likely to be sacrificed (Class II) 2 times, or 8 per cent.

Right lobe: Two parathyroids would have been sacrificed (Class III) 2 times, or 8 per cent.; two parathyroids likely to be sacrificed (Class II) once, or 4 per cent.

To estimate the risk to the individual, the percentage based upon the 50 lobes in the 25 cases must be divided by two; therefore, on the basis of these figures, the operation of unilateral intracapsular lobectomy is attended with a risk of 8 per cent. that two parathyroids will be removed; this would be increased to 14 per cent. if the doubtful cases were included.

In bilateral intracapsular removal of both lobes: 4 parathyroids would have been sacrificed (III) in one case, 4 per cent.; 4 parathyroids likely to be sacrificed (II) in two cases, 8 per cent.; endangered in 12 per cent.

TABLE III

	Apparently safe (not removed) (Class I)	Doubtful (Class II)	Probably removed (Class III)
Right superior	4	0	8
Left superior	6	4	4
Right inferior	8	2	6
Left inferior	7	3	6
Middle right[1]	1	..	..
Not classified[2]	..	..	1
	26	9	25

It must be emphasized that the relation of the parathyroids to the thyroid and its capsule is not of necessity the same for the whole set of parathyroids in an individual; that is, if one glandule is close to or at a distance from the thyroid, it does not follow that the others in the same individual are in the same relative position; such may or may not be the case, as is shown by the following analysis:

Of the ten cases in which only two parathyroids were found, in two both would have been removed; in one instance they were the two superior parathyroids and in the other the two inferior parathyroids. In four of the remaining 8 cases one parathyroid would have been removed; in three of these an inferior and in one a superior. Of the four remaining cases, in two both parathyroids would have been preserved, in one case it was doubtful whether they would have been saved, and in the fourth case one would have been saved and one was doubtful.

Of the six cases in which three parathyroids were found, in one case all three would have been removed, namely, two superiors and one

inferior. Of the remaining five cases one parathyroid would have been removed in two instances; in one the right inferior, in the other the right superior.

In the five cases in which all four parathyroids were found, in one case all four would have been removed. In another three would have been removed; namely, two inferior and a right superior. In two cases two would have been removed; namely, the left inferior and the right superior in one case and the right superior and left superior in another. In the fifth case three would have been left; the fourth parathyroid (left superior) belonged to Class II.

Conclusions.—Although these figures and deductions have been arrived at through the study of the thyroid under practically normal conditions they are presumably approximately correct even under the somewhat changed conditions which prevail in connection with enlargement of the thyroid. That parathyroids are removed frequently in goitre operations has been shown by Iversen, MacCallum and others; there is, however, marked disagreement as to the frequency with which they are thus sacrificed.

It must be emphasized that the relation of the parathyroids to the thyroid and its capsule is not of necessity the same for the whole set of parathyroids in an individual.

In the 25 cases analyzed by us one (or more) parathyroids would apparently of necessity have been removed in an intracapsular lobectomy in 21 of the 50 lobes, or 42 per cent. The significant feature, however, is that two parathyroids would almost certainly be removed in a unilateral intracapsular lobectomy in 8 per cent. of individuals, and possibly removed in 6 per cent. additional cases (*cf.* Table II).

It must be confessed that our studies have not led to conclusions which warrant recommendations for radical departure from the generally accepted operative procedures. The most that can be hoped is that they will emphasize certain important anatomical features and perhaps lead to a clearer appreciation of the reasons for certain generally accepted principles in regard to the surgery of the thyroid. These principles may be briefly reviewed.

Since usually two parathyroids lie on each side, and inasmuch as two parathyroids apparently can satisfy the demands of the body, the chance that tetany will develop as a result of extirpation of one lobe is extremely remote. It is reasonably safe, therefore, as far as tetany is concerned, to perform complete intracapsular extirpation of one lobe, as is so often done, for instance, in exophthalmic goitre.

Attention must be called to the fact that in a considerable percentage

of the reported cases of tetany which have followed operations for simple goitre the tetany has followed an operation upon the second lobe, one lateral lobe having been removed at a former operation. Such cases must be explained as follows: After extirpation of one lobe an operation upon the remaining lobe becomes necessary. Although the operator, who may be a different surgeon from the one who performed the first operation and not know the details of that operation, may elect resection or partial extirpation of the second lobe, conditions may be such as to divert him into the performance of complete extirpation of the second lobe. In such an operation parathyroids may be sacrificed, and if one or two parathyroids have already been removed in the former operation, parathyroid insufficiency and consequent tetany will result. It follows that *for the prevention of* tetany the posterior *part of the lateral lobe must always be left on at least one side;* it likewise follows that, even when one lobe only is operated upon, permanent safety is better insured by leaving *in situ* the posterior part of that lobe. Then, if a subsequent operation with complete removal or removal of the lower half of the second lobe becomes necessary, the operation may be performed with relative safety. Although the above condition rarely arises, one of the writers has seen two cases.[8]

In regard to safeguarding the recurrent nerve it may be emphasized again that in a true intracapsular extirpation of a lobe the recurrent nerve is relatively immune from injury. Nevertheless, as has been explained, the capsule may be torn at its posterior part and the cellular plane which contains the recurrent may be entered and the nerve injured. This danger is avoided by leaving a portion of the posterior part of the lobe.

To summarize: It is advantageous, but not imperative, to leave *in situ* the posterior parts of both lateral lobes in relation with each of which a recurrent laryngeal nerve and two parathyroids usually lie. Complete bilateral extirpation, the isthmus only being left, should never be considered. The posterior part of the one lobe must always be left.

The authors are indebted to Dr. Hermann Schulte and Dr. W. C. Clarke of the College of Physicians and Surgeons, Columbia University, for assistance in the preparation of this article; also to the French Hospital for the use of the laboratory.

[8] Pool: Tetany Parathyreopriva, ANN. OF SURG., 1907, xlvi, p. 507. Pool and Turnure: Post-Operative Tetany, Parathyroid Transplantation. ANN. OF SURG., 1912, lvi, p. 804.

NON-STRANGULATED DIAPHRAGMATIC HERNIA DUE TO INDIRECT INJURY*

By Donald C. Balfour, M.D.
Mayo Clinic, Rochester, Minn.

Traumatic diaphragmatic hernia though not exceedingly rare is always a surgical curiosity. The condition presents features of interest as well as problems of considerable perplexity, since the successful repair of the injury may often be associated with baffling technical difficulties. Many of the large number of cases which have been described in the literature were found either at autopsy or when operating in an emergency, immediately after the injury or later for strangulation.

Reports of the radical cure of chronic non-strangulated diaphragmatic hernia of the traumatic type are, however, surprisingly few, and particularly rare are cases in which the abdominal route has been used. Binnie,[1] in 1914, stated that two cases only of the radical cure of strangulated diaphragmatic hernia were on record. These were both repaired through the thorax. McGuire[2] has had two typical cases. He used the transthoracic operation and thinks highly of it. I have recently had the opportunity to observe and then to operate by the abdominal route on a hernia of this type, and certain points noted, particularly in reference to the diagnosis and operative treatment, seem of sufficient value to be placed on record and to warrant a description of the case.†

The patient (136,932) was a railroad conductor, forty-seven years of age, who dated all the symptoms of which he complained from a railroad accident four years ago (August, 1911) when he was crushed under logs falling from a car. The severity of the injury may be judged from the fact that he was unconscious for six days with loss of bladder control for twenty days.

The patient's subjective symptoms were briefly as follows: Following the accident and the return of consciousness he began to suffer greatly from gastric distress which continued unabated and with spells of exacerbation up to the time of our examination. The distress, which was characterized as burning and crowding pain,

* Submitted for publication October 4, 1915.

† Dr. Crispin diagnosed the case and furnished the records for the history.

at times increasing to a colic, began in the epigastrium and radiated toward the left and into the left chest. It came on, as a rule, about two hours after meals and often lasted from twelve to twenty-four hours. The first solid meal he ate, one month after the injury, "nearly killed him." Since the accident he has not been able to eat heavy food and he has never obtained relief from any kind of diet, ingestion of food always aggravating the symptoms. There was a marked dyspnœa for many days following the injury and he was not able to lie down in bed. Gradually this became less evident. He was frequently aware of gurgling and rumbling in the left chest. Strong cathartics were continually necessary and free evacuations were followed by temporary ease of abdominal distress.

Physical examination of the chest disclosed several very interesting facts. The heart was displaced to the right, lying more or less in a median position. The auscultatory signs over the left chest suggested the diagnosis. Under forced respiration splashing sounds of fluid and air were heard as high as the left nipple to the left and above the apex. There appeared to be good expansion in the left upper chest, and the breath sounds were not greatly impaired. An area of tympany existed back of the posterior axillary line and reached up to the scapula. The physical signs showed considerable variation under different postures; for example, when the patient was put in an exaggerated knee-chest position the breath sounds in the left chest became markedly suppressed and the percussion note lacked the resonance of the right side. When he was in a sitting position tympany disappeared. Litten's sign on the right side was well marked and definite; on the left side, however, it was absent and in its stead there was an upward filling of the fourth and fifth intercostal spaces anteriorly from the left sternal margin to the nipple line.

Fluoroscopic examination showed the left diaphragm at about the fifth space or sixth rib. Gas bubble in the stomach reached to the fourth rib. The left diaphragm did not reverse with respiration, but action was greatly delayed in the usual direction. The röntgenogram, after using bismuth in both stomach and bowel, showed the stomach to lie high in the left chest; it was distorted and partly rotated. The colon occupied the upper part of the left thoracic cavity, the splenic flexure rising above the level of the sternoclavicular union (Figs. 1 and 2).

In 1912 Giffin [3] made an extensive review of the literature and presented the detailed history of a patient examined and operated on by W. J. Mayo. He called attention to the important points of differential diagnosis. One of the most difficult differentiations is between trau-

matic diaphragmatic hernia due to indirect injury and elevation of the diaphragm (eventration). This depends largely on the röntgenologic findings. The most important evidences in favor of hernia are: (1) A destruction of the definite dome-shape which is characteristic of the normal line of the diaphragm; (2) the appearance of lung tissue through the gas bubble in the left chest; and (3) the demonstration of bismuth in the colon above the level of the bow-line in the chest. The findings in my case corroborate Giffin's statement as to the importance of the position of the colon with reference to the level of the bow-line in the chest. This point has not been emphasized in the literature, but the finding in my case left no doubt that the condition was due to diaphragmatic rupture rather than to elevation of the diaphragm.

Operation (August 7, 1915).—Performed under intratracheal ether anæsthesia (Robinson method and apparatus [4]) with the patient in a moderate reversed Trendelenburg position. The Bevan incision was made at the outer border of the left rectus and continued up to and along the left costal margin toward the midline, an incision similar to that used in performing splenectomy. It was immediately evident that several feet of jejunum had entered the left chest. This was removed and it was then possible to introduce a hand in front of the colon and stomach and, by careful traction on these viscera, with the aid of the hand in the thoracic cavity, all the displaced abdominal organs, except the spleen, were evacuated. This was not easily accomplished, since with each inspiration the organs were sucked back into the chest with the most surprising force and rapidity. Adhesions complicated the removal of the spleen and it was the last organ to be replaced. No serious damage was inflicted, however, the two superficial lacerations being later repaired by catgut sutures. Having succeeded in replacing the various organs in the abdominal cavity, long retaining packs were introduced, and with the aid of the spread-out hands of an assistant the stomach, colon and spleen were prevented, with considerable difficulty, from being sucked back into the thoracic cavity.

An opportunity to view the defect in the diaphragm was then afforded for the first time. The opening occupied the central part of the left half of the diaphragm; it was roughly circular in outline, with its greatest diameter anteroposterior and the average diameter about seven inches. The edges of the opening were thickened and rounded and appeared as if they would lend themselves to direct apposition without the necessity of "freshening" the edges.

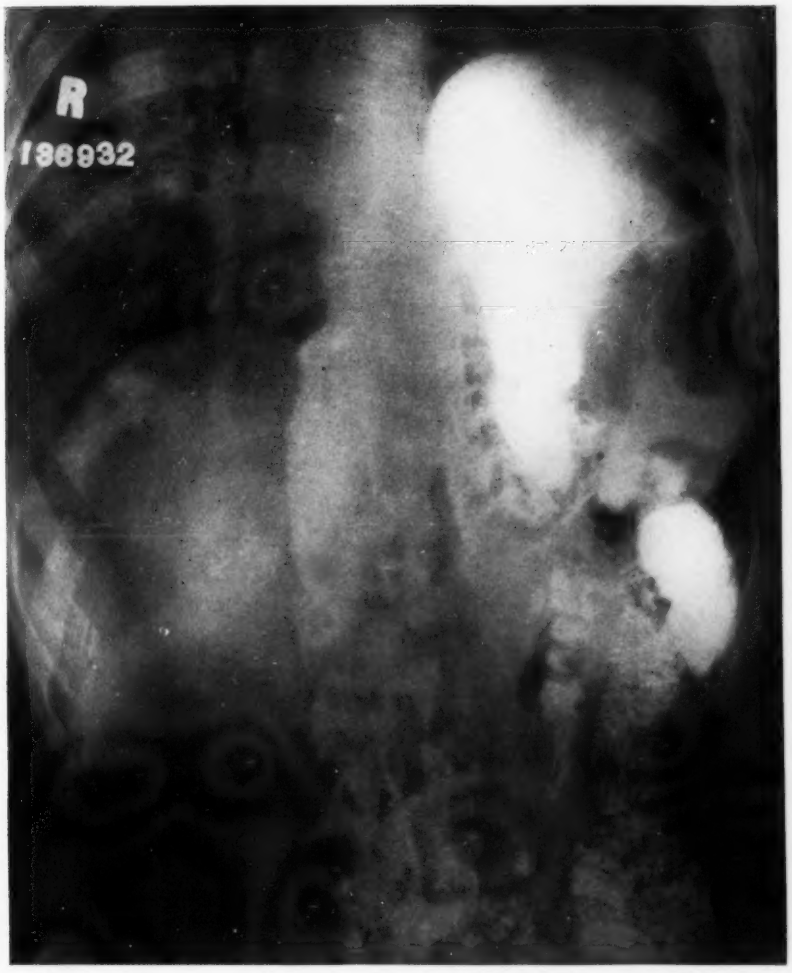


FIG. 1.—Stomach in the left chest.

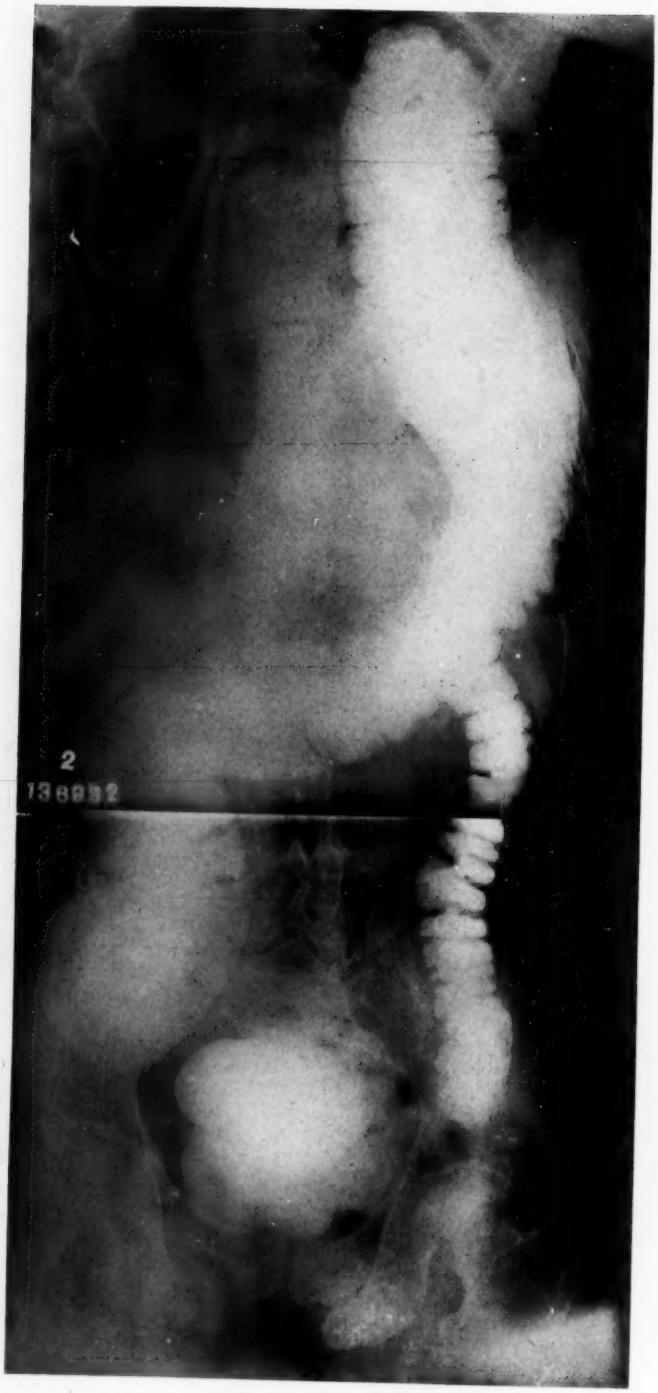


FIG. 2.—Colon in left chest.

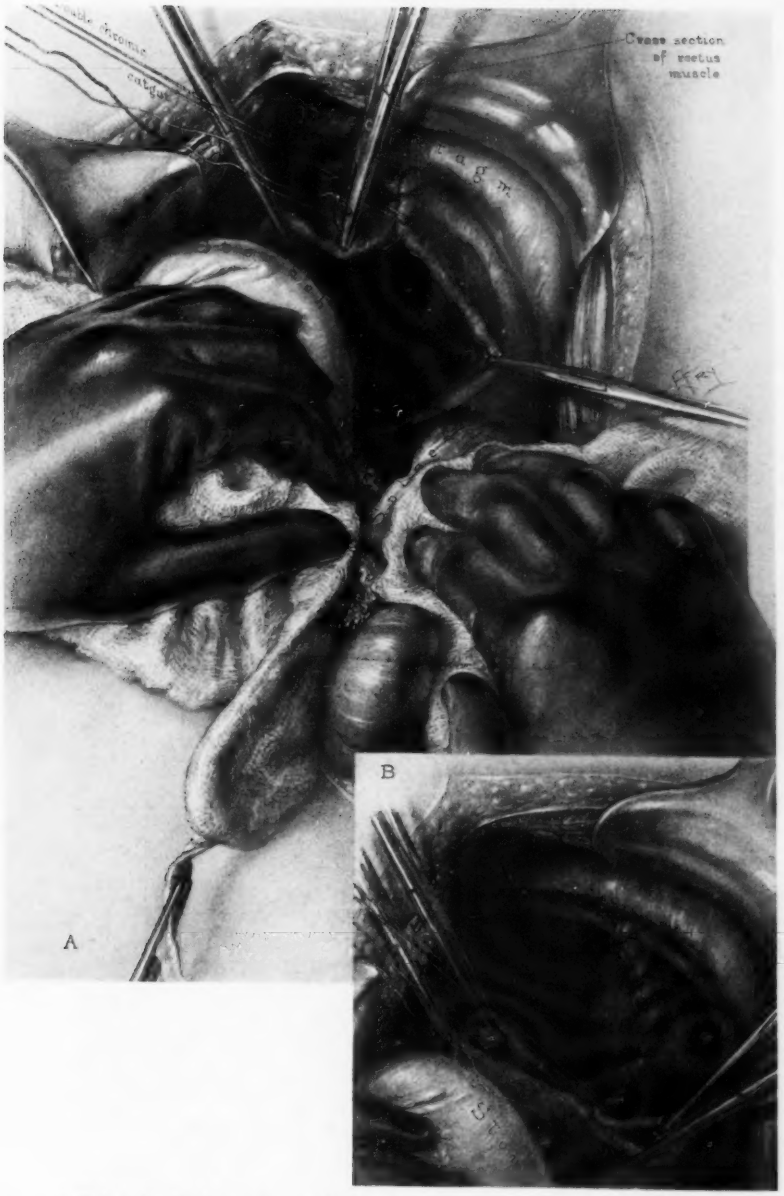


FIG. 3.—*A*. Defect in diaphragm exposed. Continuous suture of double chromic catgut begun. *B*. Method of picking up the posterior margin of diaphragmatic opening.

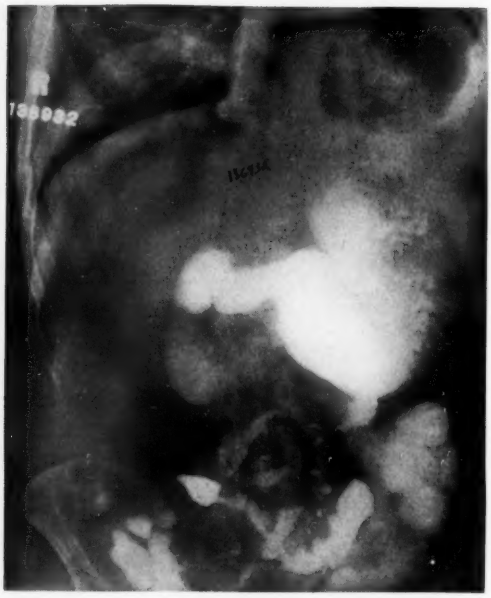


FIG. 4.—Röntgenogram of stomach following operation.

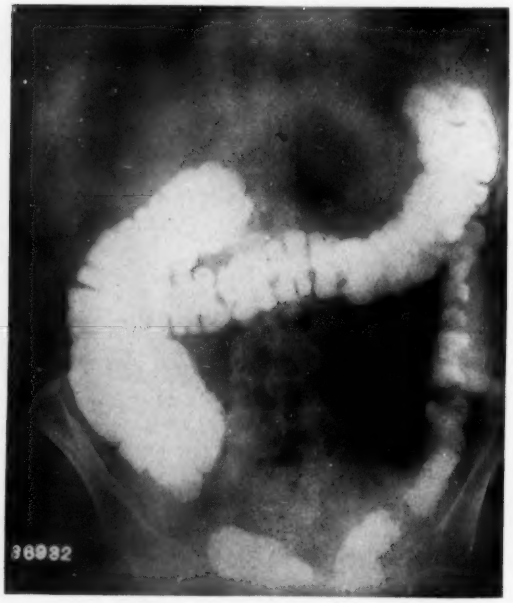


FIG. 5.—Colon following operation.

The method of closing the defect, while simple, is perhaps deserving of particular reference, as it undoubtedly facilitated a satisfactory closure. A long strand of double No. 2 twenty-day chromicized catgut was used. The suturing began at the anterior part of the opening, this being the most accessible part of the defect; the edges of the opening were approximated by the running suture, aided by traction forceps placed at suitable points beyond the margins (Fig. 3*A*). The suturing was continued until about two-thirds of the opening was closed, when it was found that the remaining posterior one-third of the defect, which was the most difficult of access, could be best obliterated by picking up the most distant edge of the opening and the closure continued on a line at right angles to the first part of the closure (Fig. 3*B*). This permitted not only complete apposition of the margins of the opening with a moderate amount of tension, but also a certain amount of overlapping. Interrupted reinforcing sutures of doubled fine silk were now used to protect the continuous line of absorbable suture material.

More careful examination of the stomach showed the presence of two ulcers, the larger one on the lesser curvature one and one-half inches from the pylorus, forming a suspiciously hard mass the size of a walnut; the second at the outlet of the stomach on the posterior wall and seemingly causing slight obstruction.

The etiologic factors of the gastric lesion are problematic, but it is very suggestive that all of this patient's gastric trouble dated from the time of his injury, and it is more than possible that the new position of the stomach in the chest, with the attendant unusual tension, thus rotating the stomach in such a way that the lesser curvature impinged on the margins of the opening, may have been the real factors in the production of the ulcers. It will be very interesting, therefore, to follow the future history of this patient to determine whether the replacement of the stomach to its normal position will be followed by relief of the gastric symptoms.

From the surgical stand-point the choice of the route used to gain access to the damaged diaphragm lies between the thoracic, the abdominal, or both. Many surgeons have advocated the transthoracic operation, but in previous cases from our Clinic reported by Beckman [5] the abdominal route seemed to be indicated. It was particularly satisfactory in the above cases. Advantages may be claimed for each method and, while in certain of the non-strangulated chronic types of diaphragmatic hernia the thoracic route may be advisable, inasmuch as complications may call for the abdominal route it is well to be familiar with the method. While Binnie's [1] excellent statistics show

a much higher mortality by the abdominal route, it should be remembered that his figures were based on emergency cases, and that in this group of acute cases (stabbing injuries, gunshot wounds, etc.) the very urgency may be due to the serious damage of abdominal viscera with the necessity for the abdominal route in these more critical cases.

The patient in this case was ready to go home three weeks after operation, when he developed a subacute intestinal obstruction and an emergency operation was done. A loop of small intestine was found adherent to the original incision. Separation of this was followed by relief of symptoms and good recovery. Thus far there has been no recurrence of gastric distress. Before he left the Clinic a careful record was made of the physical findings, which showed that the lung was rapidly expanding and the heart assuming its normal position. Röntgen examination of the stomach and colon showed them in their normal positions (Figs. 4 and 5).

REFERENCES

[1] Binnie, J. F.: Manual of Operative Surgery, Philadelphia, Blakiston, 1913, p. 573.

[2] McGuire, S.: Diaphragmatic Hernia, in his Profit and Loss Account of Modern Medicine, Richard Jenkins, 1915, 305–312.

[3] Giffin, H. Z.: The Diagnosis of Diaphragmatic Hernia, ANNALS OF SURGERY, 1912, lv, 388–397.

[4] Robinson, S.: An Apparatus for Thoracic Surgery under Intratracheal Insufflation of Positive Pressure; also for Ether Anæsthesia by Mask, Intrapharyngeal, Intratracheal and Intrabuccal Methods. Surgery, Gynæcology and Obstetrics, 1912, xiv, 462–469.

[5] Beckman, E. H.: Diaphragmatic Hernia, with Report of Three Cases. Surgery, Gynæcology and Obstetrics, 1909, ix, 154–156.

THE USE OF FREE OMENTAL GRAFTS IN ABDOMINAL SURGERY*

By Leonard Freeman, M.D.
of Denver, Colorado

Although the omentum is constantly before the abdominal surgeon, even in his way, there seems to be a general failure to recognize the important surgical uses to which it may be put, and especially is this true of free omental grafts.

A well-known function of the omentum is its almost intelligent inclination to seek out and attach itself to raw or inflamed surfaces, wrapping itself around them in such a way as to afford a maximum of protection. When the inflammation has subsided or the need for protection has ceased, these adhesions tend to disappear, however firm and voluminous they may be; so that if the abdomen is again opened, slight if any vestige of them will be found. Every surgeon must be familiar with this striking phenomenon. In other words, Nature often uses the omentum within the peritoneal cavity much as a surgeon employs adhesive plaster or a dressing externally—for temporary protection only.

This marked inclination of the intact omentum to adhere to its surroundings is also possessed by free omental grafts, which always may be transplanted with great certainty except in the presence of actual suppuration. When this fact is thoroughly appreciated the way is open to a variety of useful and even life-saving plastic procedures, such as the replacement of lost portions of peritoneum, the prevention of adhesions, the strengthening of suture lines, the occlusion of the pylorus or of the intestine, and the checking of hemorrhage.

The Replacement of Lost Portions of Peritoneum.—When this can not be done with peritoneum itself, by means of flaps, folds, or convenient transplants, an omental graft of any desirable size may be employed. The necessity for such grafting may arise anywhere in the abdomen, and the covering in of a large or even a small raw surface may sometimes prevent subsequent complications due to inflammations or adhesions. The advantage of using a free graft rather than an attached portion of omentum is obvious, because the latter may give rise to entangling bands or to injurious traction upon the colon, the duodenum or the stomach—in fact, I have seen a death from acute

* Read before the New Mexico State Medical Society, September 7, 1915.

dilatation of the stomach arising from a pull of this kind. In addition, when the omentum is permanently attached to a certain spot, its action is prevented in other portions of the abdomen where it might urgently be required.

In a number of instances I have used an omental graft to cover the large raw surface resulting from the "unfurling" of a Lane's kink, and I wish to emphasize the advantage of this and especially the security against recurrence thus obtained.

The Prevention of Adhesions.—This is a question which has given rise to much controversy, the very multitude of suggested methods serving to cast doubt upon the reliability of any particular one. However, the experiments of Sweet, Chaney and Willson [1] upon dogs, and the observations of Iselin [2] and others seem to show that the formation of permanent adhesions undoubtedly can be prevented by the use of omental grafts.

Although this may seem paradoxical at first thought, because of the tendency of the omentum to form adhesions, it ceases to be so when we remember the equally decided inclination of these adhesions rapidly to disappear when the irritative cause has subsided. In this connection an observation made by Iselin [2] is of much interest. He covered a raw peritoneal surface upon the mesentery with a free omental graft the size of the palm of a hand, and at an autopsy made seven days later the transplant was found not only grown in place, but its surface was glistening and free from adhesions. I frequently have employed transplants from the omentum to replace lost portions of the intestinal peritoneum resulting from the separation of adhesions, and although I have had no opportunity of checking up the final results by autopsy, they have nevertheless always been satisfactory.

There is but little reason to suppose that dead membranes of any kind, such as Cargile membrane (prepared peritoneum of the ox), or amniotic membrane (recently suggested by Lyman, of Denver), act otherwise than irritating foreign bodies, producing adhesions rather than preventing them, as has been demonstrated by experiments on animals made by Craig and Ellis.[3]

The Strengthening of Suture Lines in Operations Upon the Stomach and Intestines.—Free omental grafts are well adapted to this purpose, especially in the absence of great tension or of actual gaping of the wound. When those are present the use of fascia lata is perhaps to be preferred, as it also is in certain resections of the rectum and colon. The size of the transplant should be sufficient to reach well beyond the line of suture on either side, so as to obtain a firm hold upon the

adjacent surfaces, and security against displacement must be assured by numerous catgut stitches.

Pyloric and Intestinal Occlusion.—A band formed from a free omental graft may be employed to close the pylorus in gastro-enterostomy or to exclude portions of the intestinal tract, such as the proximal colon in ileosigmoidostomy. For such purposes the omentum divides the honors with fascia lata and the round ligament of the liver. The method of use is to twist a strip of omentum into a cord which is passed once or twice around the distal end of the stomach or around the bowel, drawn tight, and held by appropriate sutures. Such living ligatures do not have the same tendency as do other kinds to become absorbed or to cut their way into the lumen of the bowel; but they rather incorporate themselves with the surrounding tissues, thus insuring more or less permanent results.

The checking of hemorrhage from raw surfaces, especially of the liver, spleen and pancreas, is an important use for free omental grafts which cannot be too strongly emphasized and which I am sure is not sufficiently well understood.

An omental graft when spread upon a bleeding surface of a parenchymatous organ at once checks the oozing however free it may be, even, at times, if spurting vessels of some size are present. This is a fact first recorded by Loewy, in 1901, and since then substantiated by many observers, including the writer, both in the laboratory and in the operating room. The phenomenon is due, perhaps, partly to mechanical effect, in the shape of mere adhesion, and partly to a biochemical activity causing coagulation, which the omentum is supposed to possess in common with certain other tissues, such as fat, muscle and fascia.

It is scarcely necessary to call attention to the great usefulness of the procedure in various accidental and operative wounds of the liver and spleen. In rupture, for instance, an omental graft may be used as a tampon in place of gauze, to which it is immeasurably superior, because it is more effectual and is less likely to cause infectious difficulties and necrosis of the tissues.

Wound surfaces remaining after cholecystectomies can generally be closed by catgut sutures, but occasionally this cannot be done and great difficulty is experienced in checking the oozing which is at times alarming. Under such circumstances an omental graft pressed upon the denuded area will at once produce hæmostasis which is both reliable and permanent. In fact, the abdomen may often be closed without the usual gauze packing, so difficult and painful to remove and so often leading to troublesome after-effects, such as infection, hernia, and pro-

longed convalescence. An end of the same graft may also be used to cover the stump of the cystic duct, thus helping to insure against leakage. Of course a sufficient number of catgut sutures must be inserted to guard against shifting of the transplant; and where an actual wound of the liver is present the living tampon should often be sewed in position by sutures which penetrate deeply through both the liver and the inserted omentum.

With such a reliable aid to hæmostasis I feel sure that surgeons often should no longer content themselves in difficult cases with inefficient cholecystostomies when a cholecystectomy is really indicated. In at least two cases, for instance, I have been able to control alarming hemorrhage and easily bring to a favorable termination an otherwise fatal condition.

The technic of omental grafting is very simple, but there are certain precautions to be observed: (1) In tying off the graft a sufficient number of ligatures should be used so as not to pucker the pedicle into too much of a bunch. (2) The excision should be made as far from the base and as near the free border of the omentum as possible, and an effort made to avoid the larger vessels, for reasons mentioned farther on. (3) No more tissue should be sacrificed than is actually required. (4) The grafts should always be held in place by a number of stitches of fine catgut, in order to guard against their shifting. Silk or linen sutures are unnecessary, owing to the remarkable rapidity with which adhesion of the grafts occurs. (5) The transplant should entirely cover the raw area and project over the sound tissues on every side.

While recognizing in general the value of omental grafts, there are certain objections to them which should prevent us from employing them too hastily. They are of four kinds: (1) The production of multiple foci of hepatic necrosis; (2) the causation of gastric and duodenal hemorrhage; (3) the loss of a useful organ which might be required for other purposes; and (4) the production of a raw omental stump capable of forming objectionable or even dangerous adhesions.

No one of these objections is, however, of much force, because the probability of their occurrence is remote to say the least. The greatest interest attaches itself to gastric hemorrhage (von Eiselsberg) and hepatic necrosis (Friedrich). They are both probably due to emboli arising from thrombosis of the vessels following ligation of the omental tissues.

According to Friedrich,[4] if the thrombus is venous and extends upward far enough to reach the right epiploic vein, emboli may be washed

off and carried through the portal circulation to the liver. Small, multiple areas of necrosis are produced in this way, possibly accompanied by jaundice, thus explaining obscure instances of icterus following abdominal operations. On the other hand, if the thrombus is arterial, it may travel backward into the right epiploic artery and give rise to emboli which block the end-arteries of the stomach, causing gastric hemorrhage, usually of the "capillary" variety. It is also possible that ulcers might result in this way, as has been demonstrated by animal experimentation.

Out of a number of instances in which the omentum was ligated, I recall but two where capillary hemorrhage from the stomach occurred, neither of which was serious in its results. In fact, such happenings "belong among the rarest clinical phenomena" (Friedrich), and when they do appear the prognosis is usually good; but this should not prevent one from bearing them constantly in mind.

It is obvious from the above considerations that in ligating the omentum the larger vessels should be avoided, and that the farther the ligature is placed from the base of the structure the less the danger of a thrombus extending far enough to give rise to emboli. The anatomical peculiarity that the omentum is shorter in men than in women may have a bearing upon the interesting clinical fact that gastric hemorrhage has been observed almost exclusively in the male. When the omentum is unusually short, one should perhaps be more than usually cautious about interfering with its circulation.

LITERATURE

[1] Sweet, Chaney and Willson: ANNALS OF SURGERY, vol. lxi, p. 297, 1915.
[2] Iselin: Zeit. f. Chir., June 1, 1912.
[3] Craig and Ellis: ANNALS OF SURGERY, vol. xli, 1905, p. 801.
[4] Friedrich: Archiv. klin. Chir., B. 61, H. 4, s. 998.
[5] Crouse, Hugh: The Omentum. Its Embryology and Histology. Bull. El Paso Med. Soc., 1915.

ON LIGATION OF SPLENIC VESSELS AS A SUBSTITUTE FOR SPLENECTOMY IN BLOOD DISEASES*

ALSO A CONTRIBUTION TO THE PATHOLOGY OF THE INFARCTS OF THE SPLEEN

By Abraham Troell, M.D.
DOCENT OF SURGERY, STOCKHOLM, SWEDEN

(From the Department of Pathology, College of Physicians and Surgeons, Columbia University, New York)

The removal of the spleen—an operation which is said to have been already performed during the Middle Ages (Carstens [9]) and which nowadays without question plays the most important rôle in splenic surgery—has in the last few years been gaining a great deal as far as its indications are concerned. For, according to the experience of unquestioned authorities, it has given favorable results in certain blood diseases, particularly morbus Banti and pernicious anæmia. Banti himself as well as others[a] gives reports of cases of the former disease which, operated on in an early stage, have completely recovered and have been doing quite well as long as four years after the splenectomy. As to the pernicious anæmia certainly a perfect health has not yet been established in any case in regard either to the general condition or to the blood picture of the patient, but an improvement has been noted, in some instances so direct and striking that it could hardly be due merely to one of the ordinary fluctuations in the run of this disease.[a] Furthermore it has been shown, both by experiments and through clinical experience, that, from a physiological point of view, the spleen is not an absolute necessity for the organism. As far back as 1841 Bardeleben [19] found this to be true in animals, and numerous observations made upon patients who have undergone splenectomy have shown them to be in good health many years after, Adelmann's [18] case, for instance, 23 years. Thus there is no doubt that the operation as a matter of principle is justifiable.

* These investigations were carried out in the laboratory of Dr. W. G. MacCallum (Professor of Pathology, College of Physicians and Surgeons, Columbia University, New York) during the winter semester 1914–1915, and I am very much indebted to him, not only because he has granted me a place in his laboratory, but also for the great interest he has always shown in my work during this time and through which he in every way made it possible for me to undertake it and bring it to an end.

[a] Moynihan and Upcott, Michelsson, K. Ziegler, Poppert, Dahl, Stapelmohr, Roblee, Moffitt, Rystedt, etc.

However, it involves a considerable immediate risk. Every one who has had to operate upon individuals greatly debilitated by blood diseases, as well as he who on account of such a condition has refrained from operating, is aware of this. Splenectomy is particularly dangerous where adhesions from perisplenitis increase the difficulty in removing the organ (if not making it altogether impossible) and increase the chances for fatal bleeding.[b] In the 33 cases of splenectomy for pernicious anæmia that Moffitt has recently collected and published 8 fatalities had happened in direct connections with the operation. In Banti's disease the operative mortality is estimated at 50 per cent. (K. Ziegler). Indeed, the real mortality for all operations performed in these diseases is not small.

With this fact in view the thought has occurred to me that it might be possible to get similar results or at least nearly similar results for these patients through a simpler and less dangerous operation than splenectomy. I mean by *ligation of a larger or smaller number of splenic vessels.* Since in morbus Banti and pernicious anæmia a complete elimination of the function of the spleen has a favorable effect upon the organism, then a partial lessening of its function ought to affect the metabolism beneficially too. For a long time, and for good reasons, we have accepted an analogous way of thinking in regard to another ductless gland, viz., the thyroid, in its relation to Graves's disease. Such a clinician as Halsted, whose experience and critical way of thinking are well known, speaks in favor of this operation. And on the whole the clinical experience has proven this unmistakable, even though there has been a theoretical doubt as to the effectiveness of the operation because of the great number of anastomosing vessels, giving a very rich vascular distribution to the gland.[c]

I have searched through the literature for notes on the ligation of splenic vessels for the purpose mentioned above. The idea of this operation seems in fact so natural, that its earlier origin in the minds of others is not at all surprising. On the contrary, it is strange that it has not as yet led to the thorough investigation of its presumptive value.

In the chapter on "Surgery of the Spleen" in the large surgical text-book of Keen, Moynihan and Upcott make the following statement concerning partial ligation of the hilum of the spleen: "It has been shown experimentally that reduction of the blood-supply by ligation of some of the arterial branches entering the spleen results in atrophy of the organ, and as long as veins are left intact necrosis will not occur." However, I have not been able to get any further

[b] *Cfr.* Fischer, Roblee and others.

[c] *Vid.* for instance, Landström: Morbus Basedowii, Nord. med. arkiv., i, 1907.

information as to this investigation as no one of the papers referred to by them contains the original statement and they do not give reference to authority. Most of the other accounts in the literature concern the ligation of all splenic vessels. In order to find a method of operation in traumatic splenic bleedings—ruptures, gunshot wounds, etc.—Girgolaw and Sheldon ligated the whole hilum of the spleen in dogs, a method first advanced by Jonnesco.[28] Both undertook the operation on three dogs, all of which died from intoxication by the decomposition-products of the spleen. To prevent this, Sheldon has followed Pirone's[29] suggestion and sewed up the large omentum all around the spleen, thus hoping to get a new blood-supply to the organ. Nevertheless, the animals died after 12 to 48 hours, and at the autopsy the spleen was found necrotic throughout. The statements of Long and Lanz are based upon clinical experience, each one reporting a case of ligation of the splenic artery in "fixed floating spleen." In such a disease, not menacing the life of the patient, Lanz advises "in complicated cases," instead of splenectomy, that ligation of the splenic artery be performed as it is less dangerous but equally effective. In his case, he claims to have found clinically, half a year after the operation, a "complete disappearance" of the spleen (?). He ends his paper as follows: "If, in a case of pernicious anæmia, the chances should be in one way or another unsafe as to splenectomy, then—according to my experience—the ligation of the splenic artery might be recommended." Finally, Foà gives a quite opposite suggestion. Starting from the fact that he has seen experimental tuberculosis in the liver of guinea-pigs cured after tying the splenic vein, which organ at the same time atrophied, he thinks it might be well to ligate the splenic vein in those cases of Banti's disease in which the spleen is not removable.[d]

The suggestion of ligating a part of the splenic vessels in order to produce a reduction in the functions of the organ leads at first to the following questions:

How will the organ be affected anatomically? and what will be the result on the function of the spleen?

I have tried to get information on these subjects by experiments on animals. Having ligated one or more vessels in the splenic hilum, I have kept the animals alive a longer or shorter period, after which, through another laparotomy, I have controlled the anatomical effect. I have given particular attention to the presence or absence of infarcts in the spleen and to signs of post-operative infection. As far as the physiological side of the subject is concerned, I intended from the beginning to get light on it by counting the blood-corpuscles before the operation as well as a couple of weeks afterwards, both in the afferent and efferent splenic vessels and in a vein in some other part of the body

[d] According to Michelsson, ligation of the splenic vessels in fixed malaria-spleen has been suggested by Clement-Lucas and carried out by Meierowitsch (and Wyman?). Michelsson—who does not give the exact reference for any of these authors—does not think this operation to be preferable to splenectomy in malarial spleen.

(the ear). The difference between the number of blood-cells in the vein and in the artery of the spleen ought, if the spleen plays any rôle in regulating the quantity of blood-cells in the general circulation, to differ in these two instances, and from that difference I expected to be able to judge whether the function of the spleen has been retarded or not. Yet I may at once admit that my chances in this respect were not very great as to a positive result, since the investigations so far made on the functions of the spleen have led to contradictory conclusions. There has been attributed to the spleen, among other things, a rôle of formation of blood-cells as well as one of destruction of them. Clinicians to-day generally hold that the spleen, as far as the blood is concerned, has to destroy old, useless erythrocytes and to regulate the throwing into the circulation of new elements from the bone-marrow and other blood-forming organs.[6] There are, however, even recent investigations (Morris) which are in favor of the theory that the spleen in adults, too, is a blood-forming organ.

There is one more detail in the arrangement of my investigations to be mentioned. For, in case of success in my attempt to produce what I in the first place expected, an infarct, I had to take into consideration a fairly important point. Against the use of such an operation on human beings the objection could be made that the production of a large necrotic piece of tissue in the abdominal cavity might mean a great risk of secondary infection. Realizing this, I infected three of the animals with ligated splenic vessels through the intravenous injection of staphylococci or coli bacilli one to one and a half weeks after the primary operation.

On account of space I do not give here a detailed report of my experiments (these will soon appear in a paper in the Swedish journal, *Svenska läkaresällskapets handlinger*). However, I wish to make a few technical remarks. Before the operation I made a blood test from the ear vein of the animal and counted the number of blood-cells. All the operations were performed under ether (between 10 A.M. and 2 P.M., the animals were fed at 5 P.M.; thus a possible leucocytosis of digestion should have played about as little rôle in one case as in another). The spleen was exposed by an incision parallel to and just below the costal margin. Through a slight pulling on the stomach wall the spleen was brought outside the abdominal wound and then protected with warm saline cloths. As much care as possible was taken to avoid direct handling and squeezing of the spleen as well

[6] See Johnston, Pearce (and collaborators), Thévenot, Hedenius, Moffitt, Dahl, A. Meyer (thorough paper on the relation of the spleen to the metabolism), King, Roblee and others.

as pulling and traction upon its vessels; this in order to exclude error in the blood-counts. After having located the topography of the vessels, I first punctured a vein and then an artery with a fine suture needle. From each vessel I took blood in a pipette for white and red blood-cells and mixed as usual with Hayem's solution and $^1/_3$ per cent. acetic acid. At my first operations I also made smears for differential counts of the white blood-cells (Giemsa stain). Finally, the number of vessels I wanted to ligate were tied with a linen thread, the spleen was replaced in the abdomen, the wound closed and the animal left to recover. All counts of the blood-cells were made by myself, using a Thoma-Zeiss apparatus; 100 squares for the red cells; the whole chamber for the white being counted.

The operations were so far successful that peritonitis never occurred. Healing followed without any trouble, the animals recovered very soon after the operation and, with some few exceptions, seemed to do very well.

I performed in the beginning a series of operations on 12 animals. From 1 to 5 each of the arteries and veins in the splenic hilum were tied, always as many afferent vessels as efferent ones, and in that way, as a rule, at least one artery and one vein were left untouched; with the exception of one of the guinea-pigs where all of the vessels at the hilum of the spleen were tied.

The anatomical effect in the large animals (eight dogs and one cat) of this series was negative, so far as I could judge, in six instances but positive in three. Every one of the three guinea-pigs showed marked changes in their spleens.

In the six animals first mentioned I could not find any evident abnormality in the splenic tissue at the autopsies undertaken, 13 days to 2½ months after the operation. This was the fact even in those two cases (Nos. 2 and 6) which, having been quite well up to the time of death, died spontaneously three weeks after the operation. One dog (No. 8), however, showed, 10 minutes after the ligation, multiple infarction of the periphery of the spleen in an early stage (Fig. 5); one cat (No. 9) after five hours, showed a diffuse infarction of the organ; and another dog (No. 5) after 13 days, showed a small hemorrhagic infarct in the upper part of the spleen.

As to the guinea-pigs, the effect was more noticeable. The size of the spleen in each case was greatly reduced, in proportion to the number of vessels ligated. Thus the animal in which two arteries and two veins were left untouched at the operation, showed, 1½ months later, a spleen somewhat larger than that in which just one artery and one vein had been left; while in the guinea-pig with its whole hilum tied,

the spleen was smallest. Yet in these three animals there was a general reduction of the organ without any visible signs of infarction.

Thus the results of this series of operations in a way were not very encouraging in view of what was expected. Particularly striking was the fact that infarction in so many cases did not occur, though I sometimes ligated as many as 4 out of 5 large arteries and veins, and although I always found my ligatures all right at the autopsy. It is to be regretted that at these first operations I had not taken an exact measurement of the spleen and thus could not later on tell whether the size of the spleen in the larger animals had been reduced after the ligation of the vessels. In the guinea-pigs this was an easy matter, as the decrease was so marked.

Evidently, the cause of the non-infarction should be found in the anatomical arrangement of the vessels. And yet at first, I was unable to determine exactly how, due largely to the fact that the distinguishing of the different parts in the gastrosplenic ligament (which in dogs is very broad) had mostly become rather difficult because of adhesions and kinking after the ligation. The fact was made clear, however, through one of the animals last killed (Case 1). In this specimen it was easily seen that distal to the place of ligation (Fig. 1)—which is indicated on the photograph by a pin through a paper cross—there was a transverse, broad vascular anastomosis, establishing a communication between the periphery of the tied vessel and the non-ligated vessel nearest to it. (This was found in the artery as well as in the vein, though the figure shows only the vein which afterwards was filled with a 5 per cent. collargol solution in order to render it more visible; for the same purpose a small piece of paper was placed under it). The main reason for ligating the splenic vessels at a point situated so proximally in the hilum was a technical one. With the intention of doing a blood count from vein and artery, I wished as much as possible to avoid handling and squeezing the vessels which I was going to puncture and then ligate; otherwise a disturbance might easily have been brought about in the physiological differences which I figured to exist in the amount of blood-cells in the artery and the vein. Thus I chose proximal places because the technic became simpler in that way—yet the vascular lumina not even here being very great on the animals operated on.

When I started operating upon my first series of animals, I undertook it with the idea in mind which has been found in anatomical textbooks for a long time (*e.g.*, Henle) and according to which the arteries of the spleen do not communicate with each other, either before enter-

ing the organ or after (*cf.* Fig. 2, from Gray). I had no idea of the fact that anastomosing branches which exist between the splenic and the gastro-epiploic vessels could be so extensive as it afterwards appeared from the real effects of my ligations and as it was indicated from the findings in Case 1. Having stated this, however, I naturally felt very anxious to get reliable information on this point. Therefore I injected colored gelatine solution into the splenic arteries of fresh autopsy material, from dog as well as from man—stomach, spleen and pancreas being dissected out together.[1] There is no need of many words to emphasize how clearly the pictures (Figs. 3 and 4) bring out the rich supply of transverse communication between the vessels of the spleen hilum. The first photograph refers to the spleen of a normal dog, the second to that of a child one year old (the picture here seen was the same in principle in the other two human spleens which I examined for the same purpose). In the two cases shown in Figs. 3 and 4 the injection was performed at the point shown by the pin. After the injection, in order to show the details, all the veins as well as the peritoneal sheaths were dissected off. For the fixation 5 per cent. formalin was used. The specimens show, on the one hand, the presence not only of slight connections but also of very *wide and sturdy transverse communicating branches between the various vessels in the splenic hilum.* And, on the other hand, they present evidence that for the most part, *these transverse anastomoses are located quite close to the concavity of the spleen.* I have in many cases found them to be so distributed that one might reasonably speak of a marginal artery and vein, which is in communication with the spleen through short branches. In view of such a supply of vessels it is evident that, even without attaining an immediate and complete stoppage of the circulation, such as would be a necessary condition for infarction, it is quite possible to ligate several arterial branches, particularly by doing so at a sufficient distance from their entrance into the spleen.

By ascertaining the anatomical state of the vessels, a neglect of which explains the negative results of my first series of experiments, I found it very desirable to undertake a new series of ligations. In this series care should be taken, in order to cut off the blood supply to a certain part of the spleen, to place the ligature distal to the transverse branches extending between the individual arteries, or a supplementary ligation of the corresponding transverse anastomosing branches should be made. This second ligature should, therefore, be placed and tied in the direction

[1] For the spleen of the dog the gelatine was colored with Prussian blue, for that of the man with vermillion red.

FIG. 1.—Case I. Distal to the place of ligation, which is indicated by a pin through a paper cross. There is a transverse, broad vascular anastomosis, establishing a communication between the periphery of the tied vessel and the non-ligated vessel nearest to it.

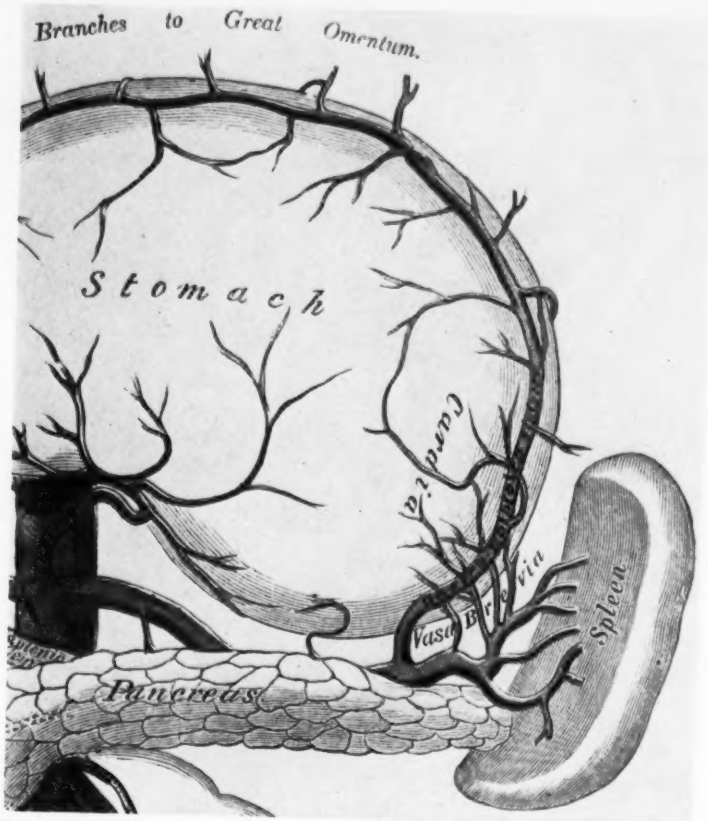
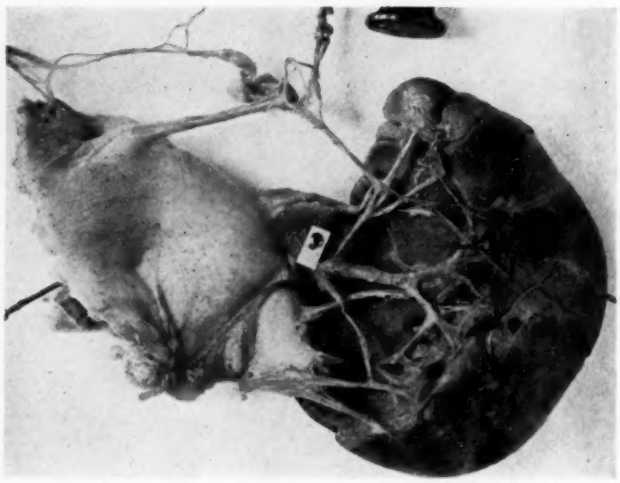


FIG. 2.—Showing that the arteries of the spleen do not communicate with each other (from Gray's Anatomy).

FIG. 3.

FIG. 4.



FIGS. 3 and 4.—From dog and man respectively. Showing the rich supply of transverse communication between the vessels of the spleen hilum; the anastomoses are located quite close to the concavity of the spleen.

FIG. 5.—Case VIII. Ten minutes old, multiple hemorrhagic infarction, localized to the edges of the spleen.

FIG. 6.—Case XXI. Three days old infarction of the lower and, to a less extent, upper poles of the spleen.

FIG. 7.—Case XX. Four and one-half weeks old infarcts, extended over the entire cross-section of the spleen. Case XVI. Spleen with its upper pole reduced to a pale shrunken infarct, 6 mm. long and 3 mm. deep; four and one-half weeks old.

FIG. 8.—Case VIII. The microscopical appearance of a ten minutes old infarct; through an enormous over-supply of red blood-corpuscles the spleen cells are made more attenuated than usual, the malpighian bodies, as well as the trabeculæ, showing no visible changes.

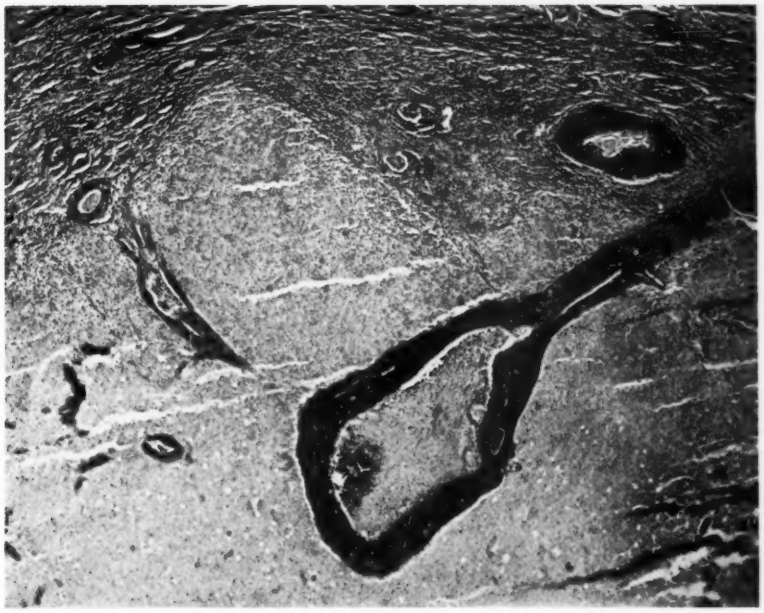


FIG 9.—Case XX. The histological picture of a four and one-half weeks old infarct, being in the state of organization; necrosis and, to a certain degree, reabsorption have begun. A part of the infarct remains in the shape of a central, hyaline, eosinophilic mass, at the periphery of which there is a reaction zone rich in cells and pigment.

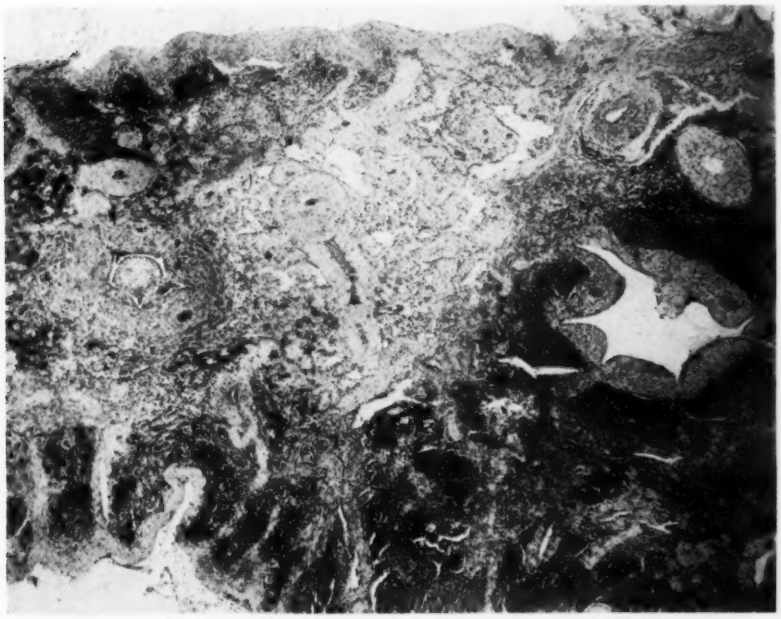


FIG. 10.—Case XVIII. The histological appearance of a four and one-half weeks old, organized infarct, consisting only of connective tissue rich in vessels, and to a great extent, sclerotic, containing pigment, intracellularly and extracellularly.

of the ligamentum gastrosplenicum, at a right angle with the first ligature.

I carried out these ligations in a number of cases, a series of nine dogs. In some I ligated only arteries, in others also veins. In all—as well as in a guinea-pig—I made exact measurements of the spleen before the ligation, for the results previously obtained with the guinea-pigs operated on (Nos. 10–12) spoke in favor of the possibility that diminished blood supply and nutrition might bring about a general reduction of the organ without producing an infarct.[g] The ligatures I arranged so that I could not see any transverse branches lying distal to them or—and this latter was as a rule much more simply and quickly done—after ligation of, say, the lower half of the spleen hilum, I drew (Cases 20–22), with the aneurism needle, another ligature from the same point of departure, the centre of the hilum, straight out in the direction of and quite close to the concave surface of the spleen. The results of these operations were much nearer what I wanted than had been the case in the first series.

It may not be out of place here to touch upon the anatomical relations of the vessels *within* the spleen. *A priori* it would be quite conceivable that they might govern the manner in which the organ would react on shutting off a part of the circulation.

The finer structure of the splenic vascular system has for a long time been the subject of active study and discussion. The point in dispute, essentially, is the manner of the connection of the most diminutive arteries with the most diminutive veins: whether the thing takes place directly, by means of a closed system of tubes, as is usually the case elsewhere in the body, or whether it makes use of the intermediation of a system of lacunæ between the arteries and veins. The latter, if it exists, would in the minds of most investigators lack an at least uninterrupted wall, and consequently grant the blood the possibility of flowing out freely from the arterial capillaries into the splenic pulp before it accumulates in the smallest vein branches. Owing to the nature of the walls of the vessels, the blood would then be able to pick its way through the entire cellular structure of the spleen pulp in the same manner as, according to the picturesque description of Henle, a liquid would through a sand-hill. Very weighty reasons have been advanced in the last few years, in support of the view that the blood, on its way through the spleen, does not need to make use of any intermediary lacunæ, but continues proceeding from vessel to vessel, within vascular walls that form an uninterrupted connected whole, which nevertheless are so constructed that both red and white corpuscles are enabled to pass through them, by the process of diapedesis (Helly, Mollier, etc.; see also Weidenreich).

[g] The measurements were taken by placing a linen thread along the surface of the spleen, thus enabling me to obtain a precise value of the size of the entire organ in various directions.

The adherents of one view as well as those of the other are accustomed to base their opinions on now injection experiments, now a direct study of microscopical sections. But there are very slight prospects that either of these methods will ever show how an arterial capillary in the spleen ends, and how a venal capillary begins.

The method I have adopted to get at the answer to this problem is to *reverse the circulation* and then to judge from the microscopical sections whether the blood in the spleen circulates through an open or closed system. I proceeded, in the case of a dog, by applying Carrel's vessel clamps, and then severing one of the spleen's main arteries and one of its main veins. Then, by means of vessel suture, or with Crile's transfusion clamp, I united the proximal end of the artery with the distal end of the vein, and the proximal end of the vein with the distal end of the artery. After a period of 24 hours, at a relaparotomy, there was no noteworthy change in the macroscopical appearance of the spleen. Microscopically, on the other hand, it was quite clear that, in that portion of the organ which corresponded to the vessels affected, the tissue was remarkably full of red blood-cells. With the exception of the follicles (Malpighian bodies) which looked normal, the field was swarming with red blood-cells and very scarce of pulp tissue. Between the "operation area" of the spleen and its normal portion, there was a transition zone in which the frequency of blood-cells was not so pronounced. I shall not here enter into any further interpretation of these sections, as they cannot be considered as in any way representing a finished investigation. Yet it seems to me that they are fully compatible—and most compatible—with the assumption of a system of closed tubes in the spleen, in which the walls of the vessels in the finer branches on the venous side are more easily passed through than on the arterial side, so that, in the former part, under the influence of the more energetic blood current, it permits the passage of the blood-corpuscles to an unlimited number, spreads the Malpighian bodies to a greater distance from each other than obtains usually and fills the spleen pulp with red cells. The great frequency of blood-corpuscles even in the arteries belonging to the Malpighian bodies may be an indication of the presence of vessel walls all over, may be of very slight resistance. If the "reversed blood" from the vein branches reached very soon intermediary wall-less lacunæ, it could hardly have succeeded in getting so far back, *i.e.*, so far into the arterial side, that even the arteries of the follicles became full of red blood-corpuscles.

After this digression, I return to the cases operated on by me (Nos. 13–22), where the ligation of vessels gave a more positive result than I had previously obtained.

Post-operative peritoneal infection did not in this series occur, but two dogs (Nos. 14 and 21) died suddenly a short time after the operation, exactly as had been the case in the first series studied. The first dog (No. 14) presented a rather bad general condition before the operation. He died on the fifth day. No other organic change could be observed than the infarction in the spleen. The other dog who died (No. 21) was a rather large animal in fairly good general condition before the operation. He died three days after four-fifths of

his spleen hilum had been ligated, and on post-mortem examination showed no other abnormality than infarction of a large section of the spleen (Fig. 6). In these cases death may have been due to an intoxication produced by decomposition products of the spleen. Considering the cases together with the manner in which the guinea-pigs operated on reacted—including the two (Nos. 12 and 13) in whom the entire spleen had been disabled, none of them showed any effect on their general condition—we are obliged to note that various species of animals do not bear equally well such a trauma as is involved in the ligation of the vessels above indicated.

As for the changes produced in the spleen itself in the second series of operations, they consisted of an infarction of a greater or less portion of the organ (Cases 14–18, 20, 21), or in a simple reduction of the volume of the spleen without demonstrable infarcts (Cases 13, 19, 22). Most striking was the effect in Case 16: Before operation the length of the spleen was 13 cm., breadth 4 cm., circumference 6 cm.; 33 days after the upper half of the hilum had been ligated, the corresponding dimensions were, 7.4, 3.2, and 6.1 cm. respectively, and the upper pole of the spleen had been reduced to a pale, shrunken infarct, 6 mm. long and 3 mm. deep (Fig. 7).

From a pathological-anatomical view-point the infarcts are very interesting, which, including both series of operations, were produced in ten cases by ligation of a greater or less number of splenic vessels. They represent, taken together, a series of changes more or less pronounced, depending upon the length of time elapsing between the ligation and the animal's death. The age of the changes was from 10 minutes to 45 days.

Even gross-pathologically, it was easy to recognize those parts of the spleen which had been deprived of their normal blood circulations. They had the characteristic appearance of hemorrhagic infarcts: a wedge-shaped area on cross-section, with clear demarcations from the rest of the organ, with, after 10 minutes, a perceptible elevation and of bluish-black color (Fig. 5). Most often (Cases 8, 9, 14, 15, 17, 20, 21) they were multiple; in only two animals were they single (Cases 5 and 16). In five cases (8, 14, 15, 18, 21) there was noticeable a localization of the infarcts to the edges of the spleen (Fig. 5), or, chiefly to one pole or to both poles (Fig. 6). In four cases only one-half of the organ was affected, but in such a manner that the infarct (Cases 5 and 16, Fig. 7) or the infarcts (Cases 17 and 20, Fig. 7) extended over the entire cross-section, and did not limit themselves to the zones along the edges. The formation of infarcts in the centre

of the spleen with the periphery uninfluenced never came to my notice; in the two cases (Nos. 1 and 2) in which the spleen hilum was ligated in the centre, no effect at all was apparent.

It should, however, be noted that this negative result is stated for the condition several weeks after the operation; the effect may have had a different appearance earlier in the process. If a considerable part of the spleen's blood supply or discharge is suddenly cut off, the immediate effect will be a more or less pronounced (depending on the case) alteration in the corresponding tissue and its appearance. In Cases 14 and 21 (Fig. 6) there was recorded, even on the fifth (or fourth, respectively) day after the ligation of the vessels, a noticeable increase in the volume of the organ,[4] because of the increase in its blood content, congestion, infarction. A similar enlargement, not, however, one that was measured precisely, was observed in Case 9 five hours, and in Case 15 two hours after the operation. A few minutes after the ligation Case 9 showed multiple small protuberances on the convex surface, but five hours later, on the animal's death, the serous surface was entirely smooth and a general infarction of the organ had begun. Thus a certain adjustment of even rather extensive disturbances of the circulation can, it seems, in various ways be accomplished in due time. And it is not certain that if the animal in question had lived longer, a regular infarct formation would have developed in all the cases which showed infarcted portions at the post-mortem shortly after the vessel ligation. Case 22 gives further strength to this statement. Here, a few minutes after the ligation, there was observed a bluish-black color of the upper half of the spleen, which was in sharp contrast to the lower half of normal coloring. But when the animal was killed, four weeks after, no trace of an infarction could be found; there was merely a distinct reduction in the volume of the entire spleen.

As for the gross-pathological picture of the infarcts thus produced, it is noteworthy, finally, that an anæmic infarct could not be positively detected in any case. In, for instance, Case 18 (in which only the arteries were ligated) the macroscopic appearance of the infarction had a hemorrhagic color still a month later. From the microscopical picture it was not evident in a single case that an anæmic infarct had been produced. This, in view of what the experience shows as to human beings—but we most likely do not have many opportunities to see very fresh human infarcts—arouses our astonishment, though it agrees

[4] All these measurements were undertaken in exactly the same manner and under entirely uniform conditions, for which reason I regard it as quite proper to speak of the dimensions comparatively.

entirely with the earlier experimental results (Karsner and Austin, 1911, who produced infarction in the spleen and kidneys of dogs by introducing a number of plant seeds into the abdominal aorta). The growing pale of the infarct occurs sometimes earlier and sometimes later than the subsiding of its peripheral surface: in Case 17, ten days after the ligation, the infarcts were pale but not depressed; in Case 5, on the fourteenth day the color was hemorrhagic but the serous surface was retracted. Older infarcts had a depressed peritoneal surface (for example, Case 18).

Under the microscope it is easy to distinguish the effect of the circulatory disturbance in the spleen, both with regard to the blood accumulated and to the tissues of the spleen itself.

Already a short time (ten minutes) after stopping the circulation, there is a noticeable enormous oversupply of red blood-corpuscles (Case 8, Fig. 8). The spleen cells are much more attenuated than usual, particularly in a zone immediately under the organ's capsule of connective tissue. This hemorrhagic tissue is not so sharply contrasted with its surroundings as the macroscopically noticeable prominences on its serous surface might lead one to suppose, but merges very gradually into the tissue of normal blood content. Everywhere pigment is found very abundantly, both intra- and extra-cellularly, and often arranged in a thin wreath corresponding to the periphery of the smaller vessels (of the capillary vein?). The Malpighian bodies are in no place saturated with blood, nor in any way altered, nor are the trabeculæ.

After two hours, still more after five hours, it becomes emphatically evident that the frequency of blood-cells is much greater in the periphery than in the central portions (Cases 15 and 9). Certain spots do, however, present a thin zone of more normal spleen tissue, adjacent to the capsule. The outlines of the red blood-corpuscles begin to merge together and are difficult to distinguish. The follicles are no longer entirely free, but show, in various places near the periphery of the spleen, that the cells are pushed apart by red blood-corpuscles.

When the infarct is three days old, it has the appearance of an eosinophilic, structureless, almost hyaline mass, in which there are scattered a small number of well-stained cell nuclei, and also a number of poorly colored ones, as well as some fragments of nuclei (Case 21). The Malpighian bodies also show poorer coloring than usual, and the trabeculæ have in some spots been necrotized. This structureless area contrasts sharply with the adjacent spleen tissue, which is otherwise normal, but full of blood; the line of demarcation itself is made up of a thin—reactive—zone, rich in cells. All these alterations, however,

are not very pronounced at so early an epoch in the case of a small infarct. The contours of the blood-corpuscles are, to be sure, disappeared even in such cases, but the necrosis is not so far advanced. The blood pigment seems nicely placed in the protoplasm of the pulp cells. In Case 14, four days old infarction, also with minor infarcts, a considerable number of red blood-cells have retained their contours. Besides it is noticeable here that the lymphocytes, in this pathological process, are the cells that offer the most resistance to necrosis, and that a comparatively unaffected spleen tissue may continue to be present in a narrow zone close to the spleen's capsule.

In the next following stage, represented in my series of infarcts—the tenth day, Case 17—infarction has already passed beyond its climax. No grouping into follicles is any longer to be detected. Necrosis and karyorrhexis are as pronounced in the periphery as they are at the centre. Regressive processes appear within the infarct, and, at the same time, reactive processes from the adjacent parts are distinctly seen in the form of tissue, connected with the trabeculæ, and rich in cells and vessels. Areas are still found which by their eosinophilic nature indicate the presence, formerly, of red blood-corpuscles, but otherwise one has a predominant impression that most of the blood has been reabsorbed. In Case 5, a case with a very small infarct, four days later the destructive processes were decidedly less apparent than in the case described above.

The next stages I had occasion to study represented infarcts that were macroscopically shrunken and organized, 4½ weeks old. In two cases (Nos. 16 and 18, Fig. 10) I had the picture of connective tissue rich in vessels, and to a great extent sclerotic, and containing pigment within the cells as well as outside of them. The spleen's capsule was thickened and it did not run along in a straight line, but was wrinkled, apparently a consequence of the general reduction in the volume of the spleen brought about by the falling away of the specific spleen tissue. Very often, though, there was found, right under the capsule, a thin layer of common spleen tissue, rich in blood, before getting to the infarcts proper. In a third case of about same age (No. 20, Fig. 9), not all of the necrotic tissue had been reabsorbed, a rather considerable part of it remained in the shape of a central, hyaline, eosinophilic mass, at the periphery of which there began a reaction zone rich in cells and pigment.

It has already been remarked that the ligation of spleen vessels in two dogs operated on (Cases 19 and 22), as well as in all the guinea-pigs operated (Cases 10–13), did not produce any noticeable infarcts

after 1 to 1½ months, but rather a general reduction of the spleen's volume (to what extent such an effect was present in the dogs lacking infarct in the first series of operations cannot be determined, as I then did not make any precise measurements of the spleen). It has likewise been pointed out above that the anatomical reasons for this effect are to be found in the extensive anastomoses between the vessels in the hilum. Macroscopically, the diminution of the organ was not so great in the case of one (No. 19) of the dogs as in that of the other (No. 22), in which the length of the spleen had in four weeks been decreased by one-fourth of the original dimension. But for both of these cases the microscopic examination gave the impression of a diminished ratio of specific spleen tissue as opposed to connective tissue; necrosis could not be detected. In the guinea-pigs it was of interest (Cases 10 to 13) to note that a very considerable diminution of the organ had begun in spite of the fact that simultaneously the entire spleen had been enveloped in adherent omentum—showing that a subsidiary collateral circulation through the spleen capsule could not be developed and thus compensate the stoppage of the blood supply through the spleen hilum.

It would be no doubt valuable to conduct a long series of operations in which the ligatures should be intentionally so placed as to prevent the formation of infarcts, that is, without making the provisions recommended above, with regard to the transverse anastomosis between the vessels. It is not improbable that it might turn out that cutting off a considerable portion of the spleen's blood-vessels leads to a general, permanent reduction of the volume of the organ, without any infarct intervening. In that case this effect—so far as the conditions may be predicated of man—must seem more ideal than the direct production of infarcts, for the risk of secondary infection of the necrotizing infarcts here disappears. Yet there was not a trace to be found of any such infection in the spleen-operated animals whom I infected intravenously with pus bacteria (Cases 4, 5 and 17); this seems to indicate that spleen infarcts in dogs are not especially susceptible to infection. Besides it may be accepted for the present, that the rich supply of vessels in the individual cases, in the spleen, may make the projected anatomical reduction of the spleen tissue somewhat uncertain and difficult to previously calculate.

My earliest spleen operations I arranged so that I might if possible get some points on the influence of the stoppages on the functioning of the spleen. Various circumstances later prevented me from continuing in this intention. In the first place, I found contradictory results even in the very first counts of blood-corpuscles. Most of the animals did

give evidence of a larger supply of red blood-cells in the blood drawn directly from the spleen (vena lienalis), than in that found in the general circulation (ear vein) and in the vessels supplying the spleen (arteria lienalis) (Cases 1, 2, 4, 5 and 7). But in a few exceptional cases the opposite was true (Cases 3 and 6). The differences in the number of blood-corpuscles in vena and arteria lienalis were, furthermore, in some cases mighty small.[4] The prospects of obtaining any conclusions from a comparison between these first differences and those that I might have obtained by counting the blood-corpuscles a few months after the formation of infarcts, were consequently very slight. All the more so since, at this later epoch, the differences, depending on the extent to which the spleen had been infarcted, would have been less than the counts before the operations. To be sure it was also the negative result with regard to the infarct in the spleen, obtained from the animals first killed, that influenced me in giving up the blood-corpuscle counts entirely. It is yet not impossible that the accomplishment of a long series of operations and blood counts might give data of value, not only as to the formation of lymphocytes, but also on that of other blood-cells in the spleen. It would be important, in this connection, in view of the active anastomosis of the splenic vessels with the vasa gastro-epiploica, to make sure that such veins in the hilum be chosen as conduct, as far as possible, only blood from the spleen.

The task I had put before me in undertaking ligation of splenic vessels was to find out whether such an operation was an advisable substitute for splenectomy in certain blood diseases. The necessary conditions for its advisability would be, on the one hand, that a simple ligation should, in the case of the individuals concerned, bring about a rather considerable reduction of the spleen, anatomically and physiologically, and, correspondingly, an improvement in the patient's condition; on the other hand, that this should be obtainable at a slighter risk to the latter than is the case in splenectomy.

My investigations, ignoring for the present what they have taught me concerning the arrangement of the vessels in the spleen hilum and concerning the pathology of infarcts of the spleen, have shown that the cutting off of the spleen vessels in the case of the animals in question in a short time led to an anatomical reduction of the spleen specific

[4] Still more inconclusive were the differences with regard to the number of white blood-corpuscles. Their number alternated, for the nine animals first operated on, between 11,000 and 30,000. Differential counts gave a figure of at most 18 per cent. of mononuclears (about 300 to 450 leucocytes were counted in each case).

tissue. It is very likely that it also involves a reduction in the work of the organ. In other words, the effect of it may be qualitatively, but not quantitatively, equivalent to the effect of extirpating the spleen. As for the risk of a simple ligation of vessels, I have been able, in the animals I studied, to determine that the dangers of secondary infection from infarcts arising after ligation are at least not great, not even in the pyogenic condition.

In view of the high operative mortality of splenectomy, as well as of its impracticability in certain cases which have perisplenitis and adhesions, it may therefore be very reasonable to ask whether such stoppage should not be resorted to in pernicious anæmia and morbus Banti. The results I obtained concerning its effect are not applicable without further question to sick human patients. What its effect will be in such cases can only be determined by clinical experience. If favorable, it is possible that the advantages of this operation over splenectomy may not lie only in its applicability to inextirpable spleens. Its simpler technic—and presumably, therefore, its lower mortality in operation—might extend the operative indications in the case of the blood affections mentioned. For by having acquired an operative method that would grant temporary relief—and that is about all splenectomy has frequently done in these cases—we also have secured the prospect that a rather large number of patients suffering from chronic anæmias, whose complete cure has thus far been not attainable by our present therapeutic methods, may be successfully treated.

NOTE.—The substance of the above essay was communicated on February 19, 1915, to the regular weekly staff-meeting of the Department of Pathology of Columbia University; the number of the *Journal of American Medical Association* that appeared two weeks later, contained an article by Roblee on "Splenectomy in Primary Pernicious Anæmia" (March 9, 1915). Here it is stated that the ligation of the spleen vessels as a substitute for splenectomy has already been tried on six patients, but with a mortality of 66 per cent. However, the reference to authority is not given, and I have not been able to find in any of the authors cited (A. R. Steele, Harris, and Hertzog—except W. Mayo, on whose advice in the same periodical, in 1910, this mode of operation was tried) any original work such as was indicated.[1] I am therefore not acquainted with the details of these cases. It is surely not unimportant how great a portion of the spleen hilum was cut off, and less

[1] I have gone through the "Index Medicus" as well as the *Jour. of the Amer. Med. Ass.* from 1910 to 1914. Possibly Roblee's remark is based on some verbal statement of the operator in question.

so, whether not only the arteries, but also the corresponding veins were ligated. The difference in sensitiveness shown in my experiments on animals, as between guinea-pig and dog, may find a parallel in the similar relation between dog and man, in other words, man may be more vulnerable to such interferences than the dog, as the dog is more vulnerable than the guinea-pig. It should not be overlooked, that in both the animals in my second operation series (Cases 14 and 21) who died spontaneously, both the supplying and discharging vessels had been ligated. In the producing of an infarct it is of no advantage to ligate veins also, but for the removal of the decomposition products of the infarct, it is more desirable to afford as good an egress for the latter as possible, it means to ligate only a few of the spleen's arteries and none of its veins.

LITERATURE

[1] Banti: Fol. hæmatol, 10, 1910, p. 33.
[2] Bircher: Deutsche Zeit. f. Chir., 92, 1908, p. 323.
[3] Coenen: Beitr. z. kl. Chir., 70, 1910, p. 539.
[4] Dahl: Hygiea, 76, 1914, p. 473.
[5] Ellenberger u. Baum: Anatomie des Hundes, Berlin, 1891.
[6] Fajans: Beit. path. Anat., 57, 1913, p. 282.
[7] Finkelstein: Roussky Chirourguitschevsky Archiv., 25, 1909, p. 327, Ref. Jour. de Chir., 3, 1909, p. 209.
[8] Fischer: Wien. med. Wochnschr., 59, 1909, p. 2506.
[9] Flammer: Beitr. z. kl. Chir., 50, 1909, p. 684, 818.
[10] Foà: Arch. de Sc. méd., 1906, 30, and other papers (*cf.* K. Ziegler, *l. c.* p. 628, 676).
[11] Fowler: Surg., Gyn. and Obst., 11, 1910, p. 133.
[12] Girgolaw: Wratschebnaja Gazeta, 1909, No. 46–47. Ref. Zentralbl. f. Chir., 37, 1910, p. 255.
[13] Gray: Anatomy, 1905.
[14] Halsted: Johns Hopk. Hosp. Bull, 25, 1914, p. 223.
[15] Hedenius: Svenska läkaresällskapets handlingar, 40, 1914, p. 258.
[16] Helly: Arch. f. mikro. Anat., 59, 1901, p.93; 61, 1903, p. 245.
[17] Henle: Anatomie des Menschen, 1880, p. 197.
[18] Hill: St. Barth. Hosp. Rev., 45, 1909, p. 43.
[19] Hoerz: Beit. z. kl. Chir., 50, 1906, p. 188.
[20] Johnston: ANNALS OF SURGERY, 48, 1908, p. 50.
[21] Karsner and Austin: Jour. A. M. A., 57, 1911, p. 951.
[22] King: Arch. Int. Med., 14, 1914, p. 145.
[23] Kirchner: Am. Jour. Obst., 59, 1909, p. 431.
[24] Lanz: Zentralbl. f. Chir., 41, 1914, p. 228.
[25] Levy: Zentralbl. f. Chir., 37, 2, 1910, p. 1577.
[26] Long: Nederl. Tijdschr. v. Geneesk., 1905. Ref. Muench. med. Woch., 1905, p. 2195.
[27] Luedke: Muench. med. Woch., 1909, p. 1469.
[28] Mayo, W. J.: Jour. A. M. A., 54, 1910, p. 14.
[29] Meyer, A.: Zentralbl. f. d. Grenzg d. med. u. Chir., 18, 1914, p. 41.

[30] Michelsson, Payr u. Küttner's: Ergebn. d. Chir. u. Orth., 6, 1913, p. 490.
[31] Moffitt: Am. J. Med. Sci., 148, 1914, p. 817.
[32] Mollier: Arch. f. mikr. Anat., 76, 1910–1911, p. 608.
[33] Moynihan and Upcott: W. W. Keen's Surgery, 6, 1913, p. 619.
[34] Mueller, G.: Diseases of the Dog, Philadelphia, 1897.
[35] Pearce, Austin, Krumbhaar a. o.: Jour. Ex. Med., 16–20, 1912–1914.
[36] Poppert, Wullstein u. Wilms: Lehrb. d. Chir., 2, 1914, p. 54.
[37] Roblee: Jour. A. M. A., 64, 1915, p. 796.
[38] Rystedt: Nord. Med. ark., ii, 1914–1915.
[39] Sheldon: Am. J. Med. Sci., 139, 1910, p. 581.
[40] Stapelmohr: Hygeia, 1914.
[41] Sutherland and Burghard: Lancet, 1910, 2, p. 1819.
[42] Thévenot: Province med., 21, 1910, p. 245.
[43] Warren: ANNALS OF SURGERY, 33, 1901, p. 513.
[44] Weidenreich: Arch. f. mikro. Anat., 58, 1901, p. 247.
[45] Ziegler, K., Payr u. Küttner's: Ergebn. d. Chir. u. Orth., 8, 1914, p. 625.

REPAIR OF SMALL VESICOVAGINAL FISTULA*

By Charles H. Mayo, M.D.
of Rochester, Minnesota

The fact that vesicovaginal fistulæ are less common than formerly is undoubtedly due to better care given women during childbirth, though the condition is still occasionally seen as the result of prolonged pressure during labor. Another, or a newer, group of cases is the result of accidental or unavoidable injuries in performing hysterectomies.

Vesicovaginal fistula is a most disagreeable and troublesome infirmity because of the constant leakage, the attendant odor, and the local irritation. As seen by the surgeon these openings, large or small, appear to be mechanically easy of closure, yet the experienced operator knows that they are often very difficult to close and that they occasionally require repeated operations. Some of the openings about the ureter and the posterior wall of the bladder with fistula leading to the vagina are best approached by the abdominal route, extraperitoneally if possible, while the large vaginal fistulæ are best repaired by free incision and good exposure, which is often more difficult than it appears.

There are many cases in which the opening is so small as to be found with difficulty. For such and for those with a lumen not exceeding a quarter of an inch the following procedure is recommended which I have successfully employed in a number of cases during the last twenty years. The procedure is so simple and so generally successful that it almost partakes of a "trick" operation. I am personally indebted to the late Dr. Bernays for the principle of the operation, though I am unable to say whether it originated with him (Fig. 1).

Operation.—An incision is made through the vaginal mucosa extending completely around the fistulous opening about a quarter of an inch or less from its margins. The vaginal mucosa is dissected toward the opening, care being taken not to break through at the margin. This makes a little cup or funnel-shaped opening projecting into the vagina. The circular dissection is carried deeper around the fistula, not approaching nearer than one-eighth of an inch to the margin, its depth penetrating to the mucosa of the bladder but not through it. This leaves a little bell or funnel-shaped opening lined with mucous membrane which is connected with the mucosa of the bladder and projects

* Read before the Western Surgical Association, December 17, 1915.

FIG. 1.—*a*, vesicovaginal fistula. *b*, inversion of vesicovaginal fistula.

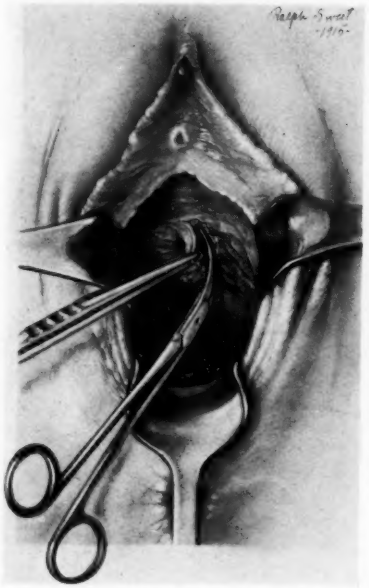


FIG. 2.—Separation of vesicovaginal fistula.

FIG. 3.—Method of inverting fistulous tract by silk sutures.

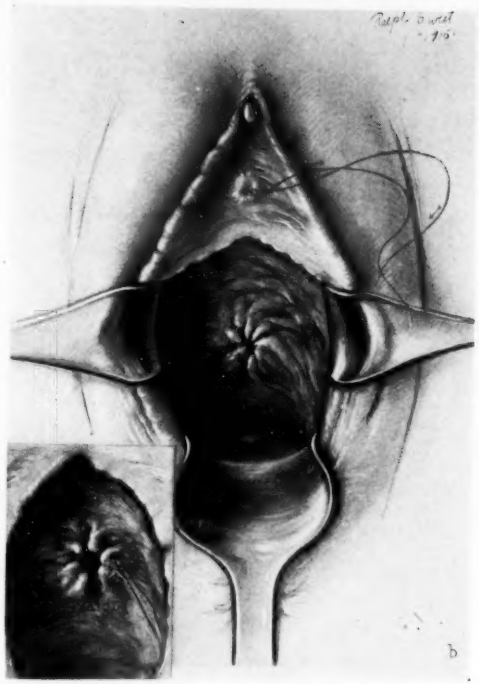


FIG. 4.—*a*, application of purse-string. *b*, fistula closed.

into the vagina (Fig. 2). A ligature carrier is passed through the urethra into the bladder and through the fistula into the vagina. A suture is passed through both walls of the funnelled mucosa on each side of the ligature carrier. The two ends of the silk suture are now threaded into the ligature carrier which is withdrawn from the bladder and urethra. The ends of the suture projecting from the urethra are drawn upon, and with a little aid the fistulous tract starts inverting (Fig. 3). As soon as the mucosa disappears a circular suture of fine chromic catgut is applied, a little more traction is used on the ends of the long suture and a second purse-string suture of catgut is applied. The vaginal side is now closed either by a circular suture of the chromic catgut or by interrupted sutures as seems best. This inversion turns the mucous surface into the bladder and leaves a healing surface within the tube. One of the long ends of the suture projecting from the urethra is re-threaded and by a needle is sutured to the skin of the labia. The two ends are now tied at this point, making slight traction. A self-retaining catheter (Pezzer type) is inserted into the bladder and the patient is instructed to rest on her side or even on her face (Fig. 4). This keeps the fistulous area free from urinary pressure. After four days it is necessary carefully to watch the catheter that sediment or phosphatic deposit does not obstruct its lumen. In some cases irrigation is necessary. However, the long suture attached to the inner side of the surface of the fistula and passing through the urethra acts as a safety valve of leakage should the catheter become temporarily plugged. After a week the repair is usually solid, but it is better to keep the patient on her side or face for a few days longer that no undue strain may be placed on the fistulous area, and during this time it is best to keep a catheter in, or if it is removed to have regular periods for passing it. The suture from within the bladder either cuts itself out with the slight traction before it is time to remove the catheter or it may be drawn out without difficulty by cutting one side where it is attached to the skin.

A METHOD FOR OBTAINING UNCONTAMINATED BLOOD FROM DOGS AND OTHER ANIMALS

By Charles Goodman, M.D.

of New York

Professor of Clinical Surgery in the New York University

(From the Laboratory of Physiological Surgical Research, New York University, and the Laboratory of Physiological Chemistry, Beth Israel Hospital)

Serology has become one of the important features of modern medicine, and is at present receiving close attention from laboratory workers. Our experiments in vascular surgery and transplantation entailed a series of serological studies, and we were confronted at the outset with great difficulties in obtaining specimens of blood from the animals without having them prove worthless for the object of the experiments. This was due to contamination or laking. These obstacles were preëminent in dogs, whose blood coagulates very quickly. On account of the fragility of the erythrocytes in this animal, the blood is handled with difficulty. Peyton Rous at a recent meeting of the Society of Biology and Experimental Medicine stated that he had overcome this inconvenience by the addition of one-eighth of 1 per cent. of gelatin to the specimen. We were unable to make use of this suggestion as it was necessary to utilize serum which was free from foreign substances.

Following the suggestions made by Besson,[1] I had attempted to obtain specimens of dog's blood from the saphenous vein, femoral vessels, the carotid and external jugular. In some instances I obtained specimens from the vein following the margin of the outer side of the ear.

After various efforts with syringes, different cannulas and aspirating needles, I found that blood obtained by a simple glass cannula introduced into the jugular vein gave us the most satisfactory results.

Among the different methods tested was aspiration of the ventricles. This required general anæsthesia in a dog and was attended with great danger to the life of the animal. The following method

[1] Besson, A.: Practical Biology, Microbiology and Serum Therapy. Fifth Edition. Translated by H. J. Hutchins. Longmans, Green and Co., Publishers, 1913, London and New York.

was devised which is exceedingly simple in its application and we wish to report its successful use in 10 consecutive experiments.

Technic.—The dog may be given a preliminary hypodermic of morphine. The external jugular was then exposed under local anæsthesia of novocaine (½ of 1 per cent.). This anæsthesia was very easily carried out in dogs. Two provisional ligatures were now passed around the vessel for the purpose of controlling the circulation. Two serrefines or flexible blood-vessel forceps might be

FIG. 1.

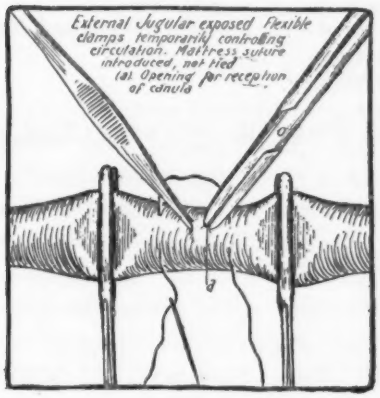


FIG. 2.

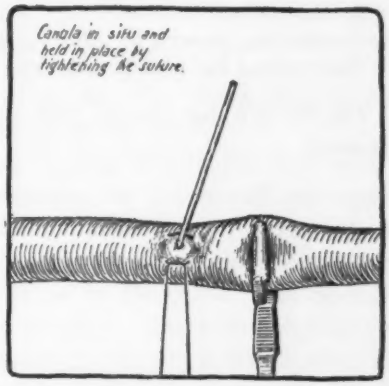
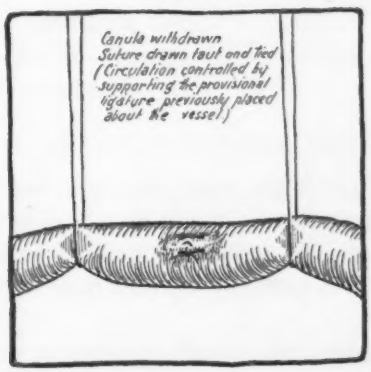


FIG. 3.



employed for the purpose. A square mattress suture of silk threaded on a fine cambric needle was passed through all the coats of the vein. An opening was made in the vein between the two arms of the mattress suture and a small glass cannula previously sterilized was inserted (without paraffin). The suture was now tightened by a slip or bow knot securing the cannula in the vessel. One of the provisional ligatures or serrefines was then relaxed, permitting the blood to flow through the cannula into the sterile test-tube or container. After the desired quantity of blood had been collected, the cannula was withdrawn and the mattress suture was drawn taut and tied. The suture approximated intima to

intima, and the wound healed without thrombosis. This little operation was completed by one or two sutures introduced into the skin. By the use of this method, various quantities of blood were obtained from the same vein at varying intervals without any evidences of thrombosis or interference with the circulation of the vessel. In order to obtain a perfectly clear serum, at the suggestion of Professor A. R. Mandel of the New York University, the tubes containing the blood were immediately placed in a dish of cracked ice. At the end of from 20 to 30 minutes, the plasma was drawn off with a pipette and later the supernatent serum was removed by the same method. The serum obtained was then centrifuged.

By this method invariably large quantities of clear serum were obtained free from corpuscles, bacteria or other contamination.

This method has greatly facilitated the work.

Thanks are due Drs. I. Seff and S. Berkowitz who assisted me in this work.

TRANSACTIONS
OF THE
NEW YORK SURGICAL SOCIETY

Stated Meeting, held October 13, 1915

The President, Dr. Frederic Kammerer, in the Chair

BULLET RETAINED IN BRAIN

Dr. Walton Martin presented a man, fifty-five years old, who had been referred to him through the kindness of Dr. Abbe.

Thirty years ago, while in Greece, he was shot in the head with a small calibre bullet. He was unconscious for six hours, but subsequently made a good recovery. Eleven years later he began having epileptic fits. He then had an X-ray picture taken which showed the bullet still in his brain. He was referred to Dr. Abbe, who operated on him twice, once in 1900 and once in 1904. The bullet was not removed, but there was a small cyst on the cortex which was opened and an area about the point of entrance of the bullet of adherent dura. He has had no recurrence of the convulsive seizures for the last two years, and is able to work hard as a cook.

Dr. Martin said that he showed him as an example of the tolerance of the brain to a foreign body.

PARTIAL GASTRECTOMY FOR CARCINOMA

Dr. Martin presented a man, thirty-eight years old, who had been sick for six months with pain in the epigastrium after taking food, and loss of weight. X-ray findings showed a distinct irregularity in contour along the greater curvature, suggesting the possibility of a new growth.

At operation four months ago the middle portion of the stomach was found puckered up by a large carcinomatous mass, extending from the greater to the lesser curvature. A midgastric resection was carried out, the severed ends of the stomach being united by layer sutures of Pagenstecher linen and chromic gut. He made a good recovery and left the hospital on the thirtieth day. The pathological diagnosis was adenocarcinoma of stomach.

The X-ray findings after this midgastric resection show the stomach in this instance to be little deformed and to empty itself fairly well.

In this case, obviously, gastro-enterostomy was out of the question. The operation done had given, at least, the patient a few months of comfortable existence.

Dr. John Douglas said that in a great number of cases of carcinoma of the stomach which looked extensive and had lasted for a considerable length of time, it was still possible to do a resection with a very fair chance of permanent relief. He recalled three cases in which he had performed a resection of the stomach, and in each of the cases though palpable glands were present, microscopical examination showed the glands not involved by the carcinoma. In one case the tumor had been present for eighteen months and the patient (a woman) is now alive three years and five months after the operation. In another case, operated upon September, 1912, the symptoms had existed six to seven months and the patient is still living and in good health. In the third case it seemed to be easier to resect the pylorus as well as the middle portion of the stomach. This patient is also alive and well almost three years after operation.

Dr. Douglas concluded that in view of these experiences, although in others recurrences or metastases had occurred, it seemed worth while to take a big chance in these cases of cancer of the stomach rather than do a temporary gastro-enterostomy, for in a fair proportion of the cases a chance of ultimate cure could be obtained.

BULLET WOUND OF KNEE AND OF POPLITEAL VEIN

Dr. James H. Kenyon presented a man who was admitted to the Hudson Street Hospital, August 14, 1915. A half hour before admission he had been shot twice in the left thigh, in the popliteal space and three inches below the great trochanter. The patient ran a block after the shooting and walked to the hospital.

Examination showed only a moderate amount of hemorrhage from the wound and no appreciable hæmatoma. General condition was good. X-ray plates showed one bullet one-half inch posterior to the mid-line of the femur and about three inches above its lower end. The other bullet was about four inches below the tip of the great trochanter, near the surface.

Although the wound showed no infection, the patient ran a temperature of 100° to 102° for four days. Operation was performed four days after admission; tourniquet applied to middle of thigh, median incision in the popliteal space, with the wound as the midpoint. Opening of the wound revealed the bullet, and was followed by a profuse hemorrhage. Pressure with the finger in the lower part of the wound con-

trolled the bleeding which came apparently from the distal part of the vein through a ragged hole through both anterior and posterior walls. The bullet was found immediately behind this opening and was apparently closing it. The bullet was flattened and had probably rebounded from the posterior surface of the femur. The popliteal vein was ligated above and below this punctured wound with plain catgut.

The other bullet was removed from just below the fascia lata. This one was not flattened, but showed on its tip a crucial incision in which a piece of cloth was tightly fastened. The patient stated that he had heard that these individual bullets had been "fixed" for him. The bullet was of 32 calibre.

The patient made an uneventful recovery and left the hospital seventeen days after the operation.

WOUNDS COMPLICATED BY FOREIGN BODIES

Dr Walton Martin read a paper with the above title, for which see page 24.

Dr. H. H. M. Lyle presented a number of photographs and radiographs taken during his recent stay in the war zone, which illustrated points bearing upon the subject. He laid emphasis on the necessity of a careful inspection of the clothing in order to detect if pieces of cloth, etc., had been carried into the wound and on the necessity of prompt routine X-ray examination of all patients. He called particular attention to the very remarkable fact that there were cases which showed wounds of "entrance and exit," yet the X-ray would reveal the presence of a shrapnel ball. Dr. Lyle stated, although this was absolutely new to him, he had found in searching the literature that Pirogoff had described this phenomenon in 1845 (Fig. 1).

Dr. Lyle said that all foreign bodies, with the possible exception of harmless rifle bullets, should be extracted as soon as circumstances would permit. Shrapnel balls and shell fragments meant imbedded clothes, dirt, straw, etc. In addition to severe primary infection it is interesting to note that cultures taken from old encysted shrapnel balls have shown tetanus bacilli in spite of previous immunization. It seems logical to assume that some of the late unexplained tetanus cases may arise from such sources. These bacteriological findings are a strong argument for the early removal of foreign bodies.

Le Fort has called attention to pseudotetanic complications caused by the presence of foreign bodies near nerve-trunks. These painful spasmodic complications simulating tetanus have in some cases gone

on so far as to threaten the life of the patient. A prompt cure is obtained by localizing and removing the irritating fragments.

Dr. Lyle said there were various methods of locating and removing bullets, shrapnel balls, and shell fragments. The Bergonie vibratory electric magnet is of special value in the removal of shell fragments, but is not applicable to lead shrapnel. The localization is determined by the intensity of the vibration of the tissues over the foreign body. It is not, as the popular belief supposes, an instrument for extraction, but one for localization. Contremoulin's directing needle and the triangulation methods are other excellent means of localization.

At Juilly, Dr. Lyle said they used the Sutton localizing trochar and cannula. Localization by directors, needles, forceps, etc., under the guidance of a fluoroscopic screen has been practised by other men, but Dr. Sutton deserves great credit for developing a simple, safe and efficient technic. The Sutton localizing technic is carried out as follows: The wounded patient is placed on a table beneath which is the X-ray tube and over him parallel to the surface is a movable fluoroscopic screen. Sufficient space is left between the screen and the patient's body to allow of the necessary instrumental manipulations. The room is darkened, the operator waiting until his eyes have become accommodated; as soon as this is accomplished the X-ray is turned on and the site of the entrance of the trochar marked by a puncture incision. The X-ray is switched off, the trochar inserted in the puncture incision, the room again darkened and, when the eye accommodation is adjusted, the X-ray is turned on. The operator now views the field through the fluoroscopic screen and advances the trochar until it impinges on the foreign body. The trochar is withdrawn, a barbed piano wire is passed through the cannula and hooked into the muscular tissue. The cannula is withdrawn and the piano wire left as a guide. The patient is then wheeled to the operating room and the foreign body removed. The advantages of this method are that the time of exposure to X-ray is short, the entire technic is carried out under local anæsthesia, no assistants are required, and no hands come in contact with the instrument, so the operator is free to carry out the necessary manipulations without breaking the aseptic technic (Figs. 2 and 3).

Dr. Willy Meyer called attention to two cases of bullet wound of the brain which he had previously presented before the Surgical Society. The first case was that of a man who had been having the first convulsions six to seven years after an injury to his brain—a pistol-shot wound with no exit. The X-ray proved the presence of the

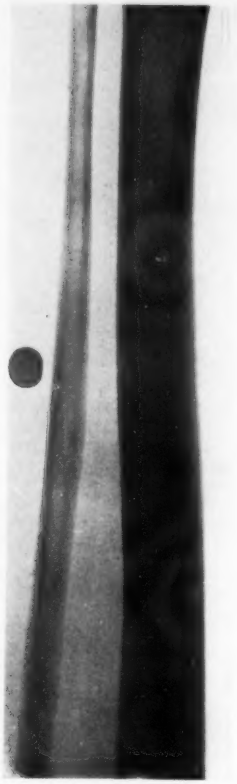


FIG. 1.—Pirogoff's phenomenon. Penetrating wound of the right leg by shrapnel. Wound of entrance one and a half inches below the tibial tuberosity; apparent wound of exit in the middle third of the calf, postero-external aspect. Ball and clothes removed.

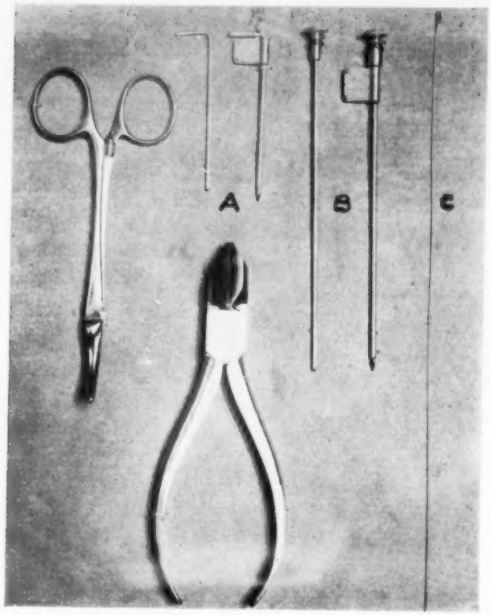


FIG. 2.—*A*, localizing trochar and cannula; the blunt trochar is used near blood-vessels and nerves. *B*, original model; the large head interfered with the sighting. *C*, hooked piano wire which is passed down the cannula and acts as guide in the operation.

FIG. 3.—The Sutton localizing method, showing the relation of patient, X-ray tube, fluoroscope screen, and the trochar and cannula.

bullet. The brain was exposed and a large cyst was found, in the depth of which the bullet was located.

The second case was that of a patient who had attempted suicide—a young man who was unfortunate enough to have had both optic and both olfactory nerves traversed by the bullet. He was immediately brought to one of the city hospitals and pulled through as far as his injury was concerned. It was difficult later on to make out the exact situation of the bullet; still, it was pretty well localized with the X-ray to be at the base of the skull. Upon turning down a temporal osteoplastic flap the bullet was found very close to the sella turcica and extracted. The patient made a good recovery and then took an ocean trip, during which he succeeded in jumping overboard.

Dr. Meyer mentioned another case of a patient who was shot in the thigh during the Civil War. There was no exit to the wound at that time. The patient recovered. Twenty years later a large abscess formed over the hip; after a sweeping operation the bullet was not found. Five to six years later he again developed an abscess and again a cause was not found. Six to seven years later he came under the care of Dr. Meyer, fortunately after the introduction of the X-ray. At the time most surgeons were attempting to make radiographs themselves, and Dr. Meyer took an X-ray and found the bullet within the lesser trochanter. Since that time the patient has been entirely well.

Dr. Meyer called attention to the fact that foreign bodies, artificially put in, first healed very nicely and then after years might cause trouble. In illustrating this point, he mentioned the case of a young man upon whom a resection of the knee-joint was done, while he was assistant abroad, where it was customary to perform this operation by placing ivory pegs in to hold the bones in place. The patient was discharged apparently well. Six to seven years later he curiously came under the care of Dr. Meyer in New York for an abscess around the resected knee. On operation it was found that one of the ivory pegs was the cause of the trouble. Dr. Meyer emphasized the point brought out by Dr. Martin, namely, that from a general point of view wounds which were made in order to extract a foreign body had to be regarded as not aseptic; and although in his early practice he closed these wounds tightly by suture, he now felt that it was very important that all these wounds should not be closed entirely, but given a chance to drain.

Dr. Eugene H. Pool mentioned a case which he had shown some years ago before the Surgical Section and which illustrated very well the point brought out by Dr. Martin in regard to the occasional tolerance of tissues to certain foreign bodies. The case was that of a man,

forty-two years old, who came to him with a tumor in the palm of the hand. The patient said that twenty-five years previously he had attempted to remove the shell from a rusty revolver held in the left hand, by hammering a nail with his right hand against the bullet end of the cartridge which was in the chamber. The shell exploded and caused a small punctured wound of the left hand, over the hypothenar eminence. No infection seems to have occurred. A short time later the patient noticed at the site of the wound a movable subcutaneous tumor, about the size of a bean. For six years before admission this tumor had increased in size.

Physical examination, prior to operation, revealed an elongated fluctuating swelling, nine centimetres long by two and a half centimetres broad, extending from one inch above the wrist downward in the middle line to the palm, where it turned gradually to the hypothenar eminence.

The cyst was dissected out. The wall was exactly as described by Dr. Martin: The outer layer of areolar fibrous tissue; a circular layer of very dense hyaline fibrous tissue; third, a layer of dense hyaline material and, fourth, a layer of cells flat and attenuated in the deeper parts and rounded near the inner surface. The contents of the cyst appeared to be composed largely of desquamated cells, also amorphous material, the nature of which could not be determined. Extensive sectioning of the cyst wall failed to show any epithelial elements. The possibility of an implantation cyst was therefore rejected. Within the cyst lay the shell of a .22 long; it was quite black.

The shells of the .22 long are usually composed of 95 per cent. copper and 5 per cent. zinc. The high percentage of copper in the small shells is necessary in order to have the shell sufficiently soft and expansible to fill completely the chamber at the time of discharge to prevent back fire.

Dr. Robert T. Morris called attention to the fact that different structures probably showed different degrees of tolerance. By way of illustration he mentioned the case of a patient whom he operated upon some years ago at the Ithaca Hospital for epilepsy. A year before he was thrown against a buzz-saw which cut through the frontal bone. Upon reaching the dura there was found at operation a piece of felt hat as big as a postage stamp, although the wound had been firmly healed. Dr. Morris ventured the opinion that the felt hat was not sterile; it was, however, walled in so kindly that none suspected the presence of a bit of felt hat, although its influence was responsible for the nervous derangement.

In another case in which very extensive adhesions of the dura were separated and a large piece of chromicized Cargile membrane inserted, Dr. Morris had occasion to open the skull some months later for a point of adhesion pain, and found that the Cargile membrane had served very well, but that it was all there, unabsorbed. It apparently had not undergone any change, nor had it caused irritation.

Dr. Morris, in commenting upon the point brought out by Dr. Lyle with regard to a bullet throwing tissue ahead of it, questioned the physics of the mechanism of the injury. He stated that the problem would be simple if one were dealing with hydrostatics, but that here we had elastic tissues and not fluid. The fact remains that tissue may be thrown ahead in that way apparently. In this connection Dr. Morris recalled a case of his in which a bullet partly encircled the chest and an "exit wound" was found, and yet when putting in the drain at that point the bullet was located beneath the skin. Dr. Morris believed that in one of the cases described by Dr. Lyle, some tissue had evidently been thrown ahead and through the skin.

Dr. B. J. Lee mentioned a case which he saw about a year ago illustrative of the effects of a foreign body in the abdominal cavity. The patient was a man in the Hudson Street Hospital upon whom a clinical diagnosis of carcinoma had been made. Upon operation a large mass about the size of a fist was found adherent to the posterior abdominal wall high up on the right side, and just below this a smaller mass which was believed to be an involved lymph-node. The smaller mass was removed and sent to the laboratory for examination. Upon looking over the records, it was found that the patient had previously had a laparotomy performed at another hospital. The pathologist found upon examination of this smaller mass a piece of cotton fibre, but upon inquiry of a junior member of the house staff was told that no previous operation had been performed. Upon the pathologist insisting that a previous operation must have been performed, questioning of the patient, who was a foreigner, developed that a previous laparotomy had been done at another hospital. It was therefore evident that the smaller tumor was a foreign-body tumor, suggesting the possibility that the larger mass was possibly also of the same character. The man refused a further exploration to determine this fact and returned to his native land and has therefore been lost sight of.

Dr. John Douglas in emphasizing the point brought out with regard to the tolerance of some patients to bullets mentioned the case of a man who had shot himself with a thirty-two calibre revolver just above and back of the ear. The patient was brought to the hospital in

a state of coma, with a bad pulse and an apparent paralysis of the right arm and leg. When he had improved sufficiently to be X-rayed the bullet was located in the left side of the brain, about one and one-half inches from the cortex. At this time the patient was delirious, with incontinence, aphasia and symptoms pointing to a complete right-sided paralysis. In view of this condition the question arose as to whether an attempt to remove the bullet by operation would be justifiable. The concurrent opinion was that death would result in any case, so it was decided to do nothing to the patient. Gradually, however, he began to improve; the incontinence, aphasia, and paralysis of the right leg disappeared, and the power in the forearm began to return. Dr. Douglas stated that when he went off the Prison Ward service of the hospital, six weeks after the admission of the patient to the hospital, the patient was able to leave the hospital and go to Court, the bullet still remaining in the brain.

In illustration of the point regarding bullets frequently not causing infection while clothing will, Dr. Douglas cited the case of a patient upon whom he operated about five or six years ago. The patient was a young man from the Bowery, a prize fighter by profession, who, while travelling about the city in an automobile visiting various primary election booths, was shot at by a rival gang, three bullets hitting him—one in the neck, another in the thigh, and the third entering over the tenth rib on the left side. Upon operation a fracture of the tenth rib was found, and a splinter of the rib had lacerated the spleen, while the bullet had badly lacerated the pelvis of the left kidney. A nephrectomy was performed, the wound in the spleen packed with gauze, and the left pleural cavity through which the bullet had passed drained. None of the bullets were removed. Later the patient was transfused from his brother, and finally left the hospital sufficiently recovered in health to enter the lists for another fight, about a year after his injuries. About three years later, however, he returned to the hospital with a small abscess over the area of the original incision, and a small piece of clothing was found walled in along the line of the original entrance of the bullet. The three bullets remained, however, never causing him any trouble.

Dr. Martin cited a case of multiple injuries illustrating one of the points referred to by Dr. Lyle. A French soldier was brought to the hospital at Juilly with fifty to sixty small wounds in his face. His eyes and forehead had escaped. These wounds were very small and irregular. Under anæsthesia a small curette passed through the openings in the skin entered in many places a considerably cavity. Particles of

loosened bone and minute fragments of a bullet were removed from many of these wounds. The soldier had been watching intently the German trench opposite him, through a loop-hole, and had apparently been hit by a German bullet which had first struck the sides of the loop-hole and been broken into minute fragments. He himself was firmly convinced that an exploding bullet had caused his injury.

In regard to the origin of late infections occurring about foreign bodies, Dr. Martin stated that there were two possibilities. A few pathogenic organisms of low virulence might be encapsulated with a foreign body and remain latent for years and yet finally cause infection through some additional trauma or lowering of tissue resistance; or the encapsulated foreign bodies might be considered a point of least resistance in the body, where pathogenic micro-organisms entering the blood-stream long afterwards would find conditions favorable for their lodgement and growth. Dr. Martin said he believed the first supposition was correct, as we know that in many instances infection is carried into the tissues by the foreign body.

Stated Meeting, held October 27, 1915

TENDON AND NERVE SUTURE AFTER WRIST WOUNDS

Dr. James H. Kenyon presented a man, thirty years of age, who was admitted to the Saint Francis Hospital, May 27, 1915, three hours after having cut his left wrist with the edge of a broken bottle.

A temporary dressing and tight bandage to control the hemorrhage had already been applied.

On admission the patient showed loss of sensation and inability to flex the fingers and thumb of the left hand. Examination showed a ragged wound extending completely across the anterior surface of the left wrist, just proximal to the joint.

A two-inch incision was made from the midpoint of this wound upward. All the flexor tendons were found to be completely divided except the one to the little finger, which was partially cut. The median and ulnar nerves were completely severed. Ulnar artery and veins were severed. Each severed tendon was united with one suture of No. 1 iodized catgut; the nerves were united with two sutures of linen placed in the edges of the nerves. Wound closed with catgut sutures, rubber tissue drain. Hand, wrist and fingers put in position of extreme flexion, moulded plaster splint applied on dorsal aspect.

Wound healed by primary union. Passive motion started on the fourteenth day, splint left off on the sixteenth day, massage, manipula-

tion and bathing in warm water and electricity were given frequently for about three months, at which time there was fairly good return of flexion power in the fingers, but to less extent in the thumb; sensation beginning to return; no power in the lumbricales or interossei.

Passive extension showed marked adherence of the scar to the sutured tendons, rendering this motion incomplete and painful. Flexion of the thumb was not as complete as that of the fingers. Because of these conditions a second operation was deemed advisable.

Second operation October 7, 1915, at the New York Hospital. Incision along the radial side of the old scar, which was found to be firmly adherent to the underlying tendons and median nerve. It was dissected free. The median nerve and also the ulnar, but to a less degree, showed a fusiform neuroma about twice the diameter of the nerve at the point of suture. This mass of tissue was dissected away until good nerve bundles were visible. With this tissue the two linen sutures employed at the first operation came away.

The long flexor of the thumb was found to be adherent to the fascia and muscle immediately beneath it, so that contractions of this muscle terminated here instead of producing flexion of the thumb. This tendon was dissected free and wrapped with Cargile membrane, which material was also used to wrap around the nerves. Wound closed with fine silk, without drainage; moulded plaster-of-Paris splint applied, with wrist straight, fingers hyperextended; primary union. Splint removed on the fifth day; active and passive motions begun; sutures removed on the eighth day.

At the present time the fingers can be readily pulled to full extension without pain; flexion of thumb much improved; sensation good. No return of power in lumbricales and interossei, as yet.

The main points to be noticed in this case are that the tendons and nerves were all cut at one level, resulting in all the subsequent sutures being placed at one level. This predisposed to the formation of adhesions between the adjacent structures and the skin, which was still further favored by the immobilization necessary to insure firm union in the divided structures.

The non-absorbable suture material in the nerve structure apparently favored the formation of the neuroma.

Dr. H. H. Lyle called attention to the necessity of the proper physiological splinting of the hand and arm and showed photographs of methods of treating gunshot wounds of the nerves, and demonstrated the Tuffier splint for drop-wrist resulting from musculospiral paralysis.

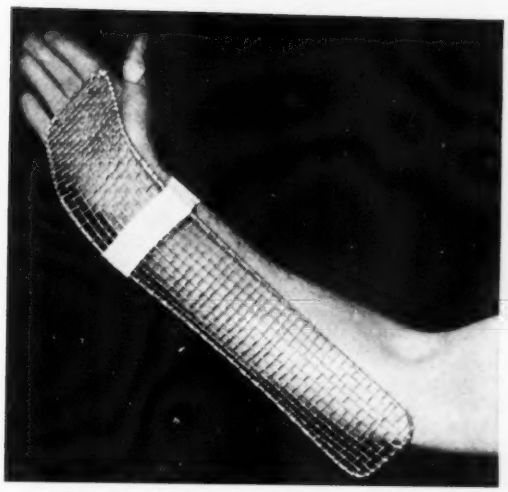


FIG. 1.—Adjustable wire splint for drop wrist.

FIG. 2.—Tuffier splint.

Dr. Lyle said that this important principle had not received from the profession the attention it deserved, hardly a text-book on neurology mentioning it. War surgery brings home the extreme gravity of an injury to an important peripheral nerve and the imperative need, whether the nerve is divided or not, of relaxing and protecting the paralyzed muscles from strain by a suitable apparatus. Unrelieved overstretched muscular tissue leads to fatty degeneration and consequent loss of contractility. Many brilliant technical operations have given disappointing functional results. The operator besides contending with the uncertainties of nerve suture has had to correct accompanying deformities and struggle against muscular degeneration. Such complications are preventable and should not occur.

In musculospiral paralysis he used an adjustable wire splint (Fig. 1) to hyperextend the hand, the thumb being abducted and the arm supinated. The hyperextension counteracts the continuous effect of gravity, relaxes the paralyzed extensors, and stretches the flexors, thus restoring the muscular balances and preventing the occurrence of a contracted drop-wrist.

The splint extended from the finger tips to the lower third of the forearm and was secured at the tendinous position of the wrist, care being taken to avoid pressure on the paralyzed muscles. As the patient improved the splint was shortened to the bases of the first phalanges. Later the Tuffier splint (Fig. 2) may be used. This is essentially an aluminum plate exactly moulded to the hand, lined with chamois and kept in place by a lacing over the back of the wrist.

In ulnar injuries the fingers were spread apart, the thumb adducted, the first phalanges flexed, the second and third extended. In median injuries the hand and fingers were strongly flexed; the thumb abducted and flexed, the arm slightly rotated. In circumflex injuries abduction of the arm was the treatment; injury to external popliteal, strong dorsal flexion with eversion.

In reply to a question as to the time of operation, Dr. Lyle said primary suture of a divided nerve is the ideal treatment but is rarely possible in war. The necessity of such an operation presupposes an anatomical division of the nerve, but there is no sure method of immediately differentiating between anatomical and physiological blocking of nerve impulses. This failure to recognize the impossibility of distinguishing between a division, a contusion and a concussion of a nerve has led to many unnecessary and harmful operations. Even if it were possible to make a diagnosis, operation is absolutely contra-indicated,

as all projectile wounds are potentially infected, and to operate in the face of infection is to court disaster. For these reasons it is best to treat all peripheral nerve lesions on an expectant plan, postponing suture until the wounds are healed. In dealing with this class of wounds Dr. Lyle said that it must be kept in mind that one is not dealing with a simple nerve but with a nerve lesion complicated by comminuted bone, torn muscles, inflammatory exudate, etc.; the whole tending to form obstinate adhesions. These conditions are treated with warm starch baths, massage, muscle kneading and systematic exercises carried out by trained assistants. The galvanic current being a good stimulant to nutrition was used, but compared with the other measures electricity plays but a minor part.

Dr. Lyle said that the postural prophylaxis begins with the reception of the wound and continues after the operation until voluntary motion is restored. A strict adherence to this vital orthopædic principle aids in the diagnosis, hastens recovery, prevents many distressing deformities, and will materially diminish the number of useless limbs.

Dr. Downes said that some three or four years ago he showed a case before the Society similar to Dr. Kenyon's, where all the flexor tendons and the median and ulnar nerves had been divided. The result was practically perfect. The girl could now play the piano.

SPLENECTOMY FOR VON JAKSCH'S ANÆMIA

Dr. Eugene H. Pool presented a child, aged eighteen months, who was admitted to the New York Hospital on April 14, 1915, with a moderate grade of rickets. She was distinctly anæmic. In addition her spleen was markedly enlarged. The examination of the blood at that time gave the following information: Wassermann reaction negative; red cells, 2,700,000; hæmoglobin, 45 per cent.; color index, 0.83; white cells, 12,000. Differential count: Polynuclears, 47 per cent.; eosinophiles, 2 per cent.; basophiles, 1 per cent.; lymphocytes, 29 per cent.; large mononuclears, 18 per cent.; irritation forms, 3 per cent. For each 100 white cells there were normoblasts, 5; megaloblasts, 7.

The blood picture remained essentially unchanged until the time of her operation. Occasionally a myelocyte was seen, but they were unusual. There was marked anisocytosis and pœcilocytosis and polychromatophilia, and many of the red cells contained basophilic granules.

On May 1 her spleen was removed. This was easily and quickly done through a vertical incision through left rectus. There were a few light adhesions to diaphragm. No transfusion was made as in the

case previously reported here. In that case there was a question as to how much the transfusion had to do with the improvement in the blood picture. In this case such a question cannot be raised. The spleen weighed 230 grammes; was 14½ cm. × 8½ × 3½ cm.

Immediately she began to show improvement. During the three weeks after the operation her red cells rose to 4,500,000 and hæmoglobin to 60 per cent. Her convalescence was interrupted by an attack of measles, which she survived, however, and she went home in fair condition. She was later sent to the country, where she continued her improvement.

When seen on October 10, five months after her operation, she was looking very well. An examination of a stained smear at that time shows a complete change in the picture. The differential count of 500 cells showed: Polynuclears, 17.2 per cent.; eosinophiles, 6.8 per cent.; basophiles, 0.2 per cent.; small lymphocytes, 55.0 per cent.; large lymphocytes, 14.4 per cent.; large mononuclears, 4.2 per cent.; transitional forms, 1.6 per cent.; irritation forms, 0.6 per cent.; red cells, 6,400,000; hæmoglobin, 52 per cent.

The red cells showed a moderate grade of central pallor and but little aniso- or pœcilocytosis. There was no polychromatophilia and no nucleated red cells were seen. Only occasionally did a red cell contain basophilic granules. There was still a moderate grade of leucocytosis; weight, 20½ pounds.

The diagnosis of von Jaksch's anæmia was made on the basis of the leucocyte count, well-marked anæmia, and a large spleen associated with rickets in an infant. This diagnosis was confirmed by the histological examination of the spleen. This organ showed the extreme grade of myeloidization of the pulp with atrophy of the Malpighian bodies, which is generally considered as characteristic of the condition. The picture in every way was similar to that seen in another case (S. K.) previously reported. In addition there was evidence of a high degree of blood regeneration, a reversion to an embryonic function of the spleen.

The case can then be definitely considered as belonging to the group known as infantile pseudoleukæmia described by von Jaksch. Following her splenectomy she improved and has continued her improvement for a period of five months. It is impossible to say, however, what is the significance of the striking change in the blood picture. The percentage of mononuclear cells is much higher than one would expect to find even in an infant and this child was two years old at the time. One can only say that following the removal of the spleen

there was a termination of a characteristic blood picture and a substitution therefor of one which we cannot as yet explain.

Her present weight is 20 pounds, red cells 6,000,000 and hæmoglobin 60 per cent. He was indebted to Dr. Ralph G. Stillman of the New York Hospital for the study and description of the blood in this case.

LEFT-SIDED APPENDICITIS COMPLICATING TRANSPOSITION OF THE VISCERA

Dr. H. H. Lyle presented a röntgenogram (Fig. 3) of a case of left-sided appendicitis occurring in a patient with a transposition of the viscera. Dr. Lyle said that the history and physical findings were typical of an acute appendicitis with abscess, the pain, tenderness and mass being on the left side. The heart was found to be on the right side. A diagnosis of left-sided appendicitis and transposition of the viscera was made and later confirmed by operation and X-ray findings. The röntgenograms of the chest showed a complete transposition of the heart to the right side, those of the abdomen a complete transposition of the colon. The cæcum was on the left side, also the major portion of the colon, the splenic flexure was low and only rudimentary (Fig. 3).

The interesting point from an operative stand-point was that the peritoneal cavity was greatly diminished in its diameter at the level of the appendix. Suspecting the possibility of a peritoneal anomaly, the incision was made within one and a half inches of the median line. An incision over the usual site would have entered the retroperitoneal aspect of the cæcum.

In reply to the question of frequency Dr. Lyle said that Dr. LeWald, Director of the X-ray service at St. Luke's Hospital, had had fourteen transposition cases, four of the heart alone and ten complete.

THE SURGICAL ANATOMY OF THE THYROID WITH SPECIAL REFERENCE TO THE PARATHYROID GLANDS

Dr. Eugene H. Pool read a paper with the above title, for which see p. 71.

Dr. John Rogers said that from an operative stand-point, these cases should be divided into two classes: First, the cystic or adenomatous goitres and, second, the exophthalmic or hypertrophied goitres. The second are usually the most vascular and present the greater operative difficulties. The dangers as regards injury to the recurrent laryngeal nerves are greatest in the second group, because of their vascularity and the consequent hemorrhage which obscures the field in the deeper

FIG. 3.—Note cæcum on left side. Röntgenogram of chest showed heart on right side. Anomalous condition of transverse colon. (Röntgenogram by Dr. L. T. Le Wald.)

parts of the neck. This leads, unless one is cautious, to the application of clamps or hæmostats to masses of tissue instead of to bleeding points, and the result is not infrequently inclusion of the recurrent nerve. He had had this occur twice in his practice with apparently permanent paralysis. At least, in neither case was there a return of motion one year and one and a half years, respectively, after the operation. In each case he discovered the accident before the wound was closed and traced the nerve through the point of compression, and so proved it had not been cut. In some cases this accident may occur in spite of every precaution. It may, if the hemorrhage is severe and from a torn and retracted artery, be practically unavoidable.

He had never been able in the course of an operation to certainly identify the parathyroid glands. Dr. Pool has excited his admiration by his ability in one case, which he demonstrated a few years ago before this Society, to find a parathyroid and to remove it and then successfully transplant it into another patient showing evidences of post-operative tetany.

Dr. Charles H. Peck said that he had followed the principle of leaving part of the gland both to protect the parathyroid and to protect the laryngeal nerve. If that is done as a routine, one practically never should lose either parathyroids or injure the laryngeal nerve. He was impressed by Dr. Rogers's remark about the possibility of injuring the laryngeal nerve by clamping. He had an unfortunate experience of that kind in the very first thyroid he had, and he had had a second experience unfortunately this summer in a very tightly-lodged intrathoracic goitre. He left a slice of the posterior capsule and cannot understand even now why he should have injured the nerve, unless he did it in clamping too close or in clamping a nerve that had been dragged forward by dislodging the lobe, which was wrapped pretty well around the trachea. If, however, one follows the principle of dissecting close to the capsule, pretty well down, then entering the capsule and leaving a thin slice of gland, one would very rarely have any trouble either with the nerve or the parathyroid.

Dr. Frederic Kammerer said that he could remember only one case of tetany following total extirpation of the thyroid, when that operation was still practised at European clinics before its deleterious effects had been established. This was a little over thirty years ago. Since that time everybody did a one-sided lobectomy and in the rare cases, in which it became necessary to remove part of the other lobe, it was always advisable to cut through the substance of the gland, leaving a shell of thyroid tissue posteriorly, which procedure prevented

exposure of the parathyroids and the recurrent laryngeal nerve. He had had the same experience as Dr. Rogers in trying to demonstrate the parathyroids during operation. He had hardly ever been able to do so, but he had invariably followed the rule, after ligating the superior thyroid vessels and raising the gland towards the median line, to cut through the capsule of the gland and to continue dissection with scissors hugging the glandular substance closely. He now felt, after seeing the instructive cross-sections presented by Dr. Pool, that he had no doubt occasionally removed parathyroids, which in his experience were much more difficult to identify than the recurrent laryngeal nerve, without any untoward symptoms resulting therefrom. The speaker frankly confessed that he had also on several occasions severed the recurrent nerve, but in his cases no permanent injury resulted from this unfortunate occurrence beyond a temporary hoarseness.

Dr. Pool said there was no attempt on his part, in presenting this subject, to suggest or to claim any departures from the generally accepted procedures and principles. The object was to demonstrate the relationship of the parathyroids, the surgical capsule and the laryngeal nerve to the posterior part of the lateral lobe. He began the work because he did not know these features himself and could not find them in any article in sufficient detail.

In regard to the case of tetany mentioned by Dr. Kammerer, he thought that case was one too many. One should not see any cases of tetany parathyreopriva.

The statement that an operator, even in a very large experience, has never seen a parathyroid in an operation upon the thyroid is not surprising, when one considers how difficult it is to find a parathyroid in an autopsy specimen. In order to locate a parathyroid in an operation one must look for it carefully in a bloodless field; even then it may be missed.

In regard to the recurrent laryngeal nerve, possibly it may do little harm to cut it on one side, but he had seen a case in which different men had cut a recurrent on each side. As a matter of fact one should not cut one at all.

It is claimed that cutting off its blood supply may produce atrophy of a parathyroid, but it is hard to understand how the same men make this statement and yet encourage transplantation of a parathyroid. Certainly the parathyroid that has not been taken out and simply has its blood supply cut off is better able to live and perhaps functionate than one which is taken from one individual and transplanted into another, or even from the same individual and transplanted into adjacent tissue.

CORRESPONDENCE

CHOLECYSTOSTOMY AND CÆCOSTOMY FOR MERCURY BICHLORIDE POISONING

EDITOR ANNALS OF SURGERY:

In the March number of *Surgery, Gynæcology and Obstetrics,* Dr. J. H. Anderson, of Pittsburgh, reports a successful treatment of a bichloride poison case by hydraulic irrigation through a cæcostomy operation performed July 21, 1914. I wish to report briefly for record two cases unsuccessfully treated similarly, one through a cholecystostomy and one through a cæcostomy opening.

The gall-bladder route was suggested to me by Dr. Ellsworth Eliot, Jr., in May, 1913, when I asked his opinion in a rather notorious bichloride case in my practice. In that case operative interference was refused and my first opportunity to try same was in the case that follows:

CASE I.—L.M.J., aged forty plus, male weighing about 160 pounds. Referred to me by Dr. W. C. Pumpelly with history of having dissolved four bichloride tablets in a glass of water and drank same. No emesis for over half an hour. Complete suppression of urine in 12 hours and same persisted on admission to Macon Hospital on December 31, 1914, thirty-one hours after taking poison. Five hours later, 36 hours after taking poison, I drained gall-bladder, opening peritoneum under novocaine and then giving small quantity of gas and oxygen, while handling gall-bladder. Murphy drip with plain water and with sodium bicarbonate instituted after 4 hours. 158, 154, 182, 176, 152, 224 ounces of water were given on successive days. No urine obtained until fourth day when 8 ounces, highly colored and large amount albumen, was obtained through catheter. Urine for next two days voided involuntarily and lost. On seventh day after operation obtained 12 ounces and a good deal was lost. Patient at this time markedly uræmic with general œdema, and died on seventh day after operation, or ninth day after taking poison.

CASE II.—Cæcostomy operation and irrigation through same. Patient referred to me by Dr. A. P. Kemp, of Macon, Ga. Young woman, aged eighteen, admitted to Macon Hospital on September 21, 1915, with history of having taken several ounces of a strong solution of bichloride three hours previous to admission. Customary treatment with emetics and lavage and magnesium

sulphate for forty hours when acute suppression of urine commenced. Referred to me twelve hours later when I performed cæcostomy under novocaine, using, as in previous case, small amount of nitrous oxide and oxygen after opening peritoneum. Murphy drip tap water started in few hours, using 178, 448, 288, 224, 240, 310, and 272 ounces of plain tap water on succeeding days. From this she secreted ½, 7, 4, 3, 2, 4 and 1 drachms of urine, dying in uræmic convulsions on seventh day after operation.

My next case I hope to get earlier and to keep in a rectal tube as suggested by Anderson.

CHARLES C. HARROLD, M.D.

Macon, Georgia.

To Contributors and Subscribers:

All contributions for Publication, Books for Review, and Exchanges should be sent to the Editorial Office, 145 Gates Ave., Brooklyn, N. Y.

Remittances for Subscriptions and Advertising and all business communications should be addressed to the

ANNALS *of* SURGERY
227-231 S. 6th Street
Philadelphia, Penna.